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Outcome comparison between open and endovascular management of axillosubclavian arterial injuries

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Background: **Endovascular repair (ER) of axillosubclavian arterial injuries is a minimally invasive alternative to open repair (OR). The purpose of this study was to compare the outcomes of ER vs OR.**

Methods: **A retrospective study was performed of patients who sustained axillosubclavian arterial injuries admitted to two high-volume academic trauma centers between 2003 and 2013. Patients undergoing ER and OR were matched according to 25 different demographic and clinical variables in a 1:3 ratio using propensity scores. The primary outcome was in-hospital mortality. Secondary outcomes were complications and length of stay.**

Results: **Among 153 patients (79.7% male; mean age, 32.7 ± 15.9 years) who sustained axillosubclavian arterial injuries, 18 (11.8%) underwent ER and 135 (88.2%) had OR. Matched cases (ER, n = 18) and controls (OR, n = 54) had similar demographic and clinical data, such as age, gender, admission systolic blood pressure and Glasgow Coma Scale score, body Abbreviated Injury Scale scores, Injury Severity Score, and transfusion requirements. Patients undergoing ER had significantly lower in-hospital mortality compared with patients undergoing OR (5.6% vs 27.8%; $P = .040$; odds ratio, 0.7; 95% confidence interval, 0.6-0.9). Similarly, patients undergoing ER had substantially lower rates of surgical site infections and a trend toward lower rates of sepsis. Outpatient follow-up was available in 88.2% (n = 15) of the patients at a median time of 8 months (1-30 months). Two ER patients required open reintervention for stent-related complications (one for a type Ia endoleak and another for stent thrombosis).**

Conclusions: **In our experience with axillosubclavian arterial injuries, ER was associated with improved mortality and lower complication rates. Patient follow-up demonstrates an acceptable reintervention rate after ER. Further multicenter prospective evaluation is warranted to determine long-term outcomes. (J Vasc Surg 2016;63:702-9.)**

Axillosubclavian arterial injuries account for approximately 5% of all vascular injuries.[1,2] Despite their low incidence, they continue to carry high morbidity and mortality.[3-5] Timely and efficacious management through an adequate open incision has traditionally been the preferred surgical approach to these injuries. However, open exposure of these vessels entails, at minimum, a clavicular incision and, in as many as 50% of the cases, associated sternotomy or thoracotomy for appropriate vessel exposure and bleeding control.[3] Open approach in this area has been viewed as challenging for many reasons, including the confined anatomic space, the high density of important neurovascular structures, the overlying skeletal cage in the apical thorax, and the risk of further injury to surrounding structures. As a result, the postoperative morbidity associated with these exposures has been high, even in the most experienced hands.

Endovascular surgery continues to enhance management options for vascular injuries, providing in many instances a safe, minimally invasive, and superior in performance alternative to open surgery. A recent study from our group has documented the rise of endovascular trauma therapy in the United States for a wide variety of vascular injuries, including aortic, iliac, and axillosubclavian arterial systems. For axillosubclavian arterial injuries in particular, a growth in endovascular utilization was demonstrated, from 0.5% in 2002 to 9% in 2010 ($P < .001$).[6]

Published experience to date in endovascular repair (ER) for axillosubclavian arterial injuries has been largely confined to case series, with a median number of two endovascular cases (range, 1-57 cases) per study as reported by DuBose et al[7] in a recent systematic review of the topic. As

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trauma centers evolve to become equipped to offer endovascular solutions on an emergent basis to bleeding trauma patients, we sought to review our experience with axillosubclavian arterial trauma and to provide a head-to-head comparison between ER and open repair (OR) for the treatment of axillosubclavian arterial injuries among civilian trauma patients admitted to two high-volume trauma centers in the United States. Our hypothesis was that ER would be associated with improved in-hospital survival and lower rates of complications, with an acceptable rate of device-related complications requiring reintervention.

METHODS

After Institutional Review Board approval, a retrospective review of the institutional trauma registries at the Memorial Hermann Hospital-Texas Medical Center, The University of Texas Medical School at Houston, and at the University of Arizona Medical Center was performed. Because of the retrospective nature of this study, no patient informed consent was required. All trauma patients who sustained axillosubclavian arterial injuries between January 1, 2003, and December 31, 2013, were identified. Patient variables abstracted included age, gender, injury mechanism, admission vital signs, Glasgow Coma Scale (GCS) score, cross-sectional imaging findings, Injury Severity Score, Abbreviated Injury Scale score for each body region, operative procedures, type and volumes of blood products transfused during hospital admission, intensive care unit length of stay (LOS), hospital LOS, in-hospital complications (acute respiratory distress syndrome [ARDS], sepsis, acute renal failure, surgical site infection [SSI], ipsilateral compartment syndrome requiring fasciotomy, ipsilateral major limb amputation, and stent-related complications), and in-hospital mortality. We also examined the causes of death in this patient cohort. ARDS was defined as the acute onset of respiratory failure and bilateral infiltrates on chest radiograph; hypoxemia was defined by a partial pressure of oxygen/fraction of inspired oxygen $\leq$200 mm Hg and no evidence of left atrial hypertension or a pulmonary capillary pressure $<$18 mm Hg (if measured) to rule out cardiogenic edema. Sepsis was defined as at least two of the following signs and symptoms of systemic inflammatory response syndrome in the presence of a positive blood culture: hyperthermia $>$38.0°C or hypothermia $<$36.0°C, tachycardia $>$90 beats/min, tachypnea $>$20 breaths/min or an arterial partial pressure of carbon dioxide $<$4.3 kPa (32 mm Hg), leukocytosis $>12 \times 10^9$/L, or leukopenia $<4 \times 10^9$/L. Acute renal failure was defined as elevation of serum creatinine concentration $\geq$2.0 mg/dL during hospitalization without antecedent renal dysfunction. SSI was defined according to the Centers for Disease Control and Prevention criteria: (1) superficial incisional, affecting the skin and subcutaneous tissue; (2) deep incisional, affecting the fascial and muscle layers; or (3) organ or space infection.

ER was performed in an endovascular suite with advanced imaging capabilities. An anesthesiologist provided airway and cardiopulmonary support. All injuries were approached percutaneously through the common femoral artery or open through brachial artery cutdown. The Seldinger technique with standard guidewires and 6F to 10F sheaths was used. The size of the device to be implanted was determined preoperatively in instances in which multidetector computed tomography angiography was available for review or intraoperatively with diagnostic angiography. Patients were prepared and draped for standard surgical repair in addition to the endovascular procedure. Prophylactic intravenous antibiotics and heparinization (if there was no contraindication) were given routinely. All procedures were performed using digital fluoroscopic guidance (isocentric mobile C-arm; Siemens, Munich, Germany) by a senior vascular surgeon.

A detailed description of the surgical technique employed for ER of axillosubclavian arterial injuries has been provided elsewhere. Briefly, access was obtained from the common femoral artery, a soft guidewire was used to access the injured vessel, and a long sheath was then inserted just proximal to the injury. The guidewire was used to traverse the lesion. Over the wire, the stent graft was delivered, deployed, and postdilated if needed. In cases in which proximal control with balloon catheter was required, the common femoral artery access was used for bleeding control and a separate brachial access was used for stent deployment.

The devices used were GORE Viabahn endoprosthesis (W. L. Gore & Associates, Flagstaff, Ariz), a reinforced, expanded polytetrafluoroethylene liner attached to an external nitinol stent structure; Wallstent (Boston Scientific, Watertown, Mass), an uncovered self-expanding stainless steel stent; and iCAST (Atrium Medical Corp, Hudson, NH), a balloon-expandable expanded polytetrafluoroethylene covered stent. The device was oversized by 10% to 20% to ensure seal (Fig 1). Postoperative follow-up focused on assessment of device patency and potential complications (eg, migration, endoleak, breakage, kinking) and the presence of any symptoms in the involved extremity. Stent patency was assessed by a surveillance protocol, which included a focused history and physical examination, peripheral pulse examination, and noninvasive imaging. Duplex ultrasonography was used to interrogate the entire axillosubclavian segment and the adjacent inflow and outflow arteries using a 5.0 or 7.5 MHz linear array probe (HDI 3000; Advanced Technology Laboratories, Bothell, Wash). Representative center-stream velocity spectra were recorded at multiple segments at a corrected Doppler angle of $\leq$60 degrees. The surveillance regimen included serial clinic visits at 1 month, 3 months, 6 months, and 12 months after surgery and annually thereafter. All imaging and surgical interventions for each patient were reviewed and tabulated.

Data were entered into a computerized spreadsheet (Microsoft Excel 2003; Microsoft Corp, Redmond, Wash) and analyzed using SPSS for Mac, version 22.0 (SPSS, Chicago, Ill).

Continuous variables were dichotomized using the following clinically relevant cut points: age ($\geq$55