

**Table.** Blood vessel characteristics before and after AVF

	Preoperative (n = 5)	Immediately postop (n = 2)	1 month postop (n = 2)	Mature (>1 year) (n = 2)
<b>Brachial artery</b>				
Diameter, mm (SD)	4.5 (0.48)	5.4 (0.56)	5.1 (0.41)	4.9 (1.8)
Average velocity, cm/s (SD)	5.5 (3.2) <sup>a</sup>	62 (17) <sup>a</sup>	70 (7) <sup>a</sup>	112.5 (57) <sup>a</sup>
Volumetric flow, mL/min (SD)	56 (33) <sup>a</sup>	850 (58) <sup>a</sup>	878 (225) <sup>a</sup>	1120 (236) <sup>a</sup>
<b>Cephalic or basilic vein</b>				
Diameter, mm (SD)	3.7	4.8 (0.05)	4.7 (1.3)	13.2 (7.2)
Average velocity, cm/s (SD)	2.25	55 (17)	64 (14)	15.7 (9.7)
Volumetric flow, mL/min (SD)	14.8	596 (201)	733 (530)	1054 (492)
Percent of blood flow in the distal artery	N/A	30%	17%	6%
Percent of blood flow in the venous limb	N/A	70%	83%	94%

<sup>a</sup>*P* < .01, ANOVA.

protocol consisted of 2D and 3D time of flight (TOF) sequences performed at 1.5T (Siemens Avanto, Germany). Through-plane blood flow velocities in the artery and vein were measured 3cm above the anastomosis with a 2D phase contrast (PC) sequence. CE-MRA was done with superparamagnetic iron oxide particles (ferumoxytol, AMAG, Lexington MA). Computational fluid dynamics (CFD) simulations were performed using a finite volume solver to determine velocity field and wall shear stress distributions (Fluent, Lebanon NH).

**Results:** Twelve subjects (median age 67 years, IQR 59-76) had 22 scans. Among patients with a brachial artery AVF, the average arterial diameter increased while arterial velocity and volumetric flow both increased by 20 times, *P* < 0.01. Both vein diameter and volumetric flow increased after AVF surgery (Table). CFD demonstrated decreasing blood velocities and asymmetric wall shear stress mappings along the AVF from 5 to 90 days postop. Importantly, areas of stagnation persisted during this critical time frame. Compared to TOF, ferumoxytol-enhanced MRA significantly increased spatial resolution, increased fistula coverage (12.8cm vs 6cm) and decreased imaging time (20 sec vs 3 min).

**Conclusions:** Development of a rapid, high-resolution MRI protocol with CFD models, allowed for a comprehensive characterization of blood vessel structure and hemodynamic forces in newly created and mature AVFs. This MRI protocol is now being used prospectively to investigate the relationship between hemodynamic forces, blood vessel remodeling and AVF maturation. Additionally, ferumoxytol in CE-MRA shows promise as a safe, non-invasive method for evaluating AVFs, especially non-maturing AVFs and potentially other vascular structures in patients with end-stage renal disease.

#### Important Predictors of DWI Lesions and Neurological Sequelae Following Carotid Intervention

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**Objectives:** Embolic detection on diffusion weighted imaging (DWI) by magnetic resonance imaging (MRI) is a promising outcome measure for carotid interventions. We previously reported that patients undergoing carotid artery stenting (CAS) have a 50% greater chance of developing new microemboli on DWI compared to carotid endarterectomy (CEA). We sought to re-evaluate these outcomes in a larger patient set after technical modifications to our CAS program. We also examined the risk factors for DWI lesions and correlated neurologic symptoms with DWI-derived MLV.

**Methods:** From July 2004 to December 2010, a total of 228 patients (143 CEA, 85 CAS) who underwent carotid interventions also received preoperative and postoperative DWI evaluations at a single academic institution. A novel neuroimaging analysis technique was used to derive MLV on DWI. Hospital records for all patients were reviewed for comorbidities, lesion characteristics, postoperative outcomes, and incidence of periprocedural microemboli.

**Results:** Forty patients (47%) with CAS compared to 15 patients (10%) with CEA had postoperative DWI lesions (*P* < .01), and a higher incidence of contralateral microembolization (*P* = .01). Multivariate analysis demonstrated that the strongest predictors of DWI lesions after CAS or CEA were body mass index (BMI) > 30 (*P* < .01; confidence interval [CI], 1.4-8), preoperative stroke (*P* < .01; CI, 2.9-15.3), chronic obstructive pulmonary disease (COPD; *P* = .03; CI, 1.1-6.2), and coronary artery disease (CAD; *P* = .05; CI, 1-6.2; Table). Subset analysis of MLV demonstrated a significant correlation with the incidence of postoperative neurological symptoms (*P* = .04; *R*<sup>2</sup> 0.248). MLV was not different between CAS and CEA (*P* = .13).

**Conclusion:** The incidence of microembolic events after CAS is higher compared to CEA, but the MLV is similar for the two groups. DWI-derived MLV highly correlates with postprocedural neurological sequelae. Further investigational use of periprocedural DWI is needed to determine the utility and cost-effectiveness of identifying patients at risk of neurological sequelae after carotid intervention.

**Table.** Multivariate analysis of perioperative factors

Factor	<i>P</i> value	CI
Age >70	.70	5.2-2.6
Gender	.09	0.02-1.3
Smoking	.68	0.4-1.9
Hypertension	.53	0.1-3.4
Hyperlipidemia	.89	0.2-5.3
Obesity (BMI >30)	< .01	1.4-8
CAD	.05	1-6.2
COPD	.03	1.1-6.2
PVD	.16	0.2-1.3
Preoperative stroke	< .01	2.9-15.3
Carotid lesion calcification		

BMI, Body mass index; CAD, coronary artery disease; CI, confidence interval; COPD, chronic obstructive pulmonary disease; PVD, peripheral vascular disease.

#### Upregulation of Mitochondrial Chaperone Proteins in Vein Grafts: A Potential Mechanism of Apoptosis-Resistance in the Arterialized Vein

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**Objectives:** Resistance to apoptosis is a salient feature of neoplasia and neointimal hyperplasia. In cancer, a mitochondrial chaperone network consisting of heat shock proteins (HSP)75 and HSP90 mediates apoptosis-resistance. We hypothesize that these mitochondrial proteins regulate survival in venous smooth muscle cells (VSMC) after arterialization, and may be critical in the hyperplastic response.

**Methods:** Primary cultured VSMC from human saphenous veins were stimulated with platelet-derived growth factors (PDGF)-BB (100 ng/mL) or tumor necrosis factor- $\alpha$  (TNF- $\alpha$ ; 10 ng/mL) for 24 hours. Cells were fractionated for immunoblotting and cytosolic and mitochondrial fractions probed for HSP75 and HSP90. Excised segments of diseased human vein grafts (n = 12) and control saphenous veins (n = 10) were obtained from discarded specimens. Rabbits (n = 9) underwent carotid interposition vein grafting and grafts were harvested on day 5 or 28. Specimens were stained for HSP75, HSP90, or the inducible isoform HSP90 $\beta$ .

**Results:** Immunoblotting showed that HSP90 and HSP75 were expressed primarily in the cytosol and mitochondria of VSMC, respectively. Mitochondrial HSP75 was significantly increased after either cytokine or growth factor stimulation in vitro. After arterialization, HSP75 expression was notably increased in all vein grafts. In the rabbit, both early (5 days, n = 2) and late (28 days, n = 7) vein grafts had significantly greater HSP75 staining throughout the intima and media as compared to absent or minimal expression in control jugular veins (n = 9; analysis of variance [ANOVA];

$P < .05$ ). Human vein grafts (age 84-1330 days) showed significantly increased HSP75 expression in the intima and media as compared to controls ( $P < .05$ ). Early vein grafts (<365 days,  $n = 3$ ) may have greater relative HSP75 expression than late vein grafts (>365 days;  $n = 9$ ) (ANOVA;  $P < .05$ ). Both saphenous veins and human vein grafts had positive staining for HSP90 and weaker staining for HSP90 $\beta$  in the intima and media.

**Conclusions:** Upregulation of the mitochondrial chaperone protein HSP75 after venous arterIALIZATION may promote a state of relative apoptosis-resistance within VSMC in the healing graft wall. Further studies are underway to determine the specific role of these proteins in vein graft remodeling.

#### Vasospasm as a Novel Mechanism to Explain Claudication in Female Athletes with External Iliac Arterial Endofibrosis

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**Objective:** External iliac arterial endofibrosis (EIAE) is rare and has been described primarily in endurance male cyclists. Clinically it presents as claudication during maximal exercise with quick resolution postexercise. Most patients are found to have fibrotic changes within the external iliac artery (EIA). We describe our experience with EIAE and propose a hypothesis for the mechanism involved.

**Methods:** This was a retrospective review of athletes who presented with symptomatic EIAE requiring an operative repair between 2001 and 2010. Data collected included demographic information, initial presentation, type of exercise, method of repair, and long-term outcome. Diagnostic studies consisted of duplex scan evaluation, modified exercise treadmill test, and angiography.

**Results:** Seven patients, all female, presented with symptomatic EIAE. All were endurance athletes (2 cyclists, 1 runner, 4 both cyclists and runners). Median age at presentation was 42.5 years (range, 39-60 years). Median duration of symptoms was 5.5 years (range, 2-15 years). Two patients had bilateral EIAE. Diagnosis was confirmed with an exercise treadmill test modified to accommodate the high level of conditioning these patients exhibited and unmask the claudication. In 2 cases, there was marked EIA vasospasm noted postexercise by duplex scanning. All cases were treated by EIA vein patch angioplasty. Follow-up ranged from 1 to 10 years. All had a normal modified exercise treadmill test and resumed their athletic activities postoperatively. In 2 cases, there was a recurrence of symptoms associated with vasospasm in the unpatched EIA segments. In 1 case, there was onset of claudication and documented postexercise vasospasm of the EIA in the contralateral leg.

**Conclusions:** This is the largest reported series of female endurance athletes with EIAE and highlights a possible mechanism to explain this disease entity as a pathologic response to exercise-induced high blood flow leading to EIA vasospasm, not vasodilation. This suggests that repetitive injury leads to endothelial dysfunction of the regenerated EIA endothelium. We recommend vein patch angioplasty as a durable repair for this condition.

#### Increased Transfusion of Autologous Blood but not Plasma is Associated with Improved Survival in Ruptured Abdominal Aortic Aneurysms

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**Objectives:** The resuscitation of ruptured abdominal aortic aneurysm (rAAA) patients has not been well-studied and the potential benefit of autotransfusion (AT) is unknown. Increased use of plasma (fresh frozen plasma [FFP]) is associated with decreased mortality in trauma patients and may improve rAAA mortality. We explored the influence of AT and FFP resuscitation on mortality in massively transfused (MT) patients with rAAA.

**Methods:** A single-center review of the medical records of patients with rAAA from April 1989 to October 2009 was undertaken. Clinical data and outcomes were studied. Operative and anesthesia records were queried for intraoperative transfusion totals, MT was defined as  $\geq 10$  units of red blood cells (RBCs) inclusive of AT units.

**Results:** One hundred fifty-one rAAAs were identified, 89 (60%) received MT. In-hospital mortality was 44%. Univariate predictive of mortality included increased age, preoperative hypotension, operative blood loss, and crystalloid, RBC, and FFP volume. Eighty-five patients received AT, with an increased ratio of AT: packed red blood cell (PRBC) units associated with survival. Mortality was 34% with AT: PRBC  $\geq 1$  (HIGH AT) and 55% with AT: PRBC less than 1 (LOW AT,  $P = .03$ ). On multivariate analysis, age  $>74$  ( $P = .03$ ), preoperative systolic blood pressure (SBP)  $<90$  mm Hg ( $P = .06$ ), blood loss  $>6L$  ( $P = .06$ ), and LOW AT ( $P = .02$ ) independently predicted mortality. Mean RBC: FFP ratios were similar in those that died (2.7) and lived (2.9;  $P = .66$ ). RBC: FFP  $\leq 2$  (HIGH FFP) was present in 38 (43%) patients, with mortality of

49%. RBC: FFP less than 2 (LOW FFP) had 40% mortality ( $P = .39$ ). Over time, RBC: FFP ratios decreased from 3.6 (1989-1999) to 2.2 (2000-2009;  $P < .001$ ), but the more liberal use of FFP was not associated with decreased mortality (47% vs 41%;  $P = .56$ ). AT: PRBC ratios were stable over time (1.4-1.2;  $P = .18$ ).

**Conclusion:** Greater use of AT but not of FFP was associated with survival in massively transfused patients with rAAA. We did not see a mortality benefit with increased FFP, but few patients had high FFP transfusion ratios. Further study to identify patients with rAAA at risk for massive transfusion should be undertaken and a potentially greater role for AT in rAAA resuscitation investigated.

#### The Impact and Outcomes of Establishing an Integrated Interdisciplinary Team to Care for Patients with Diabetic Foot Ulcers

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**Objective:** The purpose of this study was to quantify the impact of an integrated diabetic foot surgical service on outcomes.

**Methods:** We abstracted registry data from 48 consecutive months at a single institution, evaluating all patients with diabetic foot complications requiring foot surgery or vascular intervention. We compared outcomes in the 24 months before and after integrating podiatric surgery with a vascular surgical limb-salvage service.

**Results:** The service performed 2923 operations; 790 operations (27.0%) were related to the treatment of diabetic foot complications in 374 patients. Of these, 502 operations were classified as nonvascular diabetic foot surgery and 288 were vascular interventions. Overall, one third of patients required vascular intervention, initially endovascular in 86.5% of patients. Conversion to open bypass was required in 29.2% of these patients, more than double the revision rate of those receiving open bypass first (13.1%). After team integration, vascular reconstructions increased 44.2%. This increase held true for both endovascular (26.7% increase) and open interventions (88.2% increase), with a trend toward more infrageniculate vascular procedures (43.2% vs 57.7%;  $P = .02$ ; odds ratio [OR] = 1.8). After team integration, the percentage of urgent operations was significantly reduced (74.4% vs 51.8%;  $P < .0001$ ; OR = 2.7), and the high/low amputation ratio decreased from 0.34 to 0.26, ( $P < .0001$ ) due to an increase in midfoot amputations (6.7% vs 11.6%;  $P < .08$ ; OR = 1.8). Below knee amputations (BKAs) were reduced 45.7% with a relatively stable above knee/below knee amputation (AKA/BKA) ratio (0.73-0.81).

**Conclusions:** Creation of an interdisciplinary vascular and podiatric surgical team significantly impacts surgery type and volume. Significantly more nonurgent operations are performed with a decrease in the high/low amputation ratio. Vascular surgery volume is significantly increased, especially with regard to open infrageniculate procedures. While endovascular procedures have become increasingly applicable, open bypass remains critical to success.

#### Operative Management of Neurogenic Thoracic Outlet Syndrome in the Adolescent

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**Objectives:** Neurogenic Thoracic Outlet Syndrome (TOS) in adolescents is an uncommon condition where neurovascular compression may result in incapacitating symptoms. Teenage athletes may also have their academic and competitive careers placed in jeopardy. We have reviewed our experience with neurogenic TOS in adolescents to better define the presentation, diagnosis, and results of surgical intervention.

**Methods:** A retrospective review of our database identified patients 19 years of age and younger, presenting with neurogenic TOS who underwent surgical decompression. Patient characteristics on presentation, preoperative testing, surgical course, and follow-up data were all collected.

**Results:** From 1996 to 2009 a total of 20 patients (19 female, 1 male) underwent surgery for neurogenic TOS. Twelve were student athletes. Presenting symptoms included upper extremity paresthesia ( $n = 19$ ), pain ( $n = 18$ ), weakness ( $n = 9$ ), and hand atrophy ( $n = 2$ ). Symptoms affected the dominant limb in 80% and were bilateral in 45%. Preoperative evaluation included a combination of anterior scalene muscle block ( $n = 11$ ) and electromyography or nerve conduction studies ( $n = 16$ ). Nonoperative therapy was attempted but failed in all. The surgical approach was a transaxillary first rib resection (TAFRR) in 19 and transaxillary scalene muscle resection (TASMR) in 1 patient. Intraoperative findings included the presence of four cervical ribs, seven scalene minimus muscles, and 4 patients had both. There were no perioperative