

Selected Abstracts from the July Issues of the Journal of Vascular Surgery and the Journal of Vascular Surgery: Venous and Lymphatic Disorders[☆]

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Early extubation is associated with reduced length of stay and improved outcomes after elective aortic surgery in the Vascular Quality Initiative

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Objective: Timing of extubation after open aortic procedures varies across hospitals. This study was designed to examine extubation timing and determine its effect on length of stay (LOS) and respiratory complications after elective open aortic surgery.

Methods: We studied extubation timing for 7171 patients undergoing elective open abdominal aortic aneurysm repair (2687 [37.5%]) or suprainguinal bypass for aortoiliac occlusive disease (4484 [62.5%]) from October 2010 to April 2015 in hospitals participating in the Vascular Quality Initiative (VQI). Our primary outcome was prolonged LOS (>7 days), and the secondary outcome was respiratory complications (pneumonia or reintubation). The association between extubation timing and outcomes was assessed using multivariable logistic regression mixed-effects models that adjusted for confounding factors at the patient and procedure level. A variable importance analysis was conducted using a chi-pie framework to identify factors contributing to the variability of extubation timing.

Results: The 7171 patients undergoing abdominal aortic surgery were a mean age of 65.4 (standard deviation, 10.2) years, and 63% were male. Extubation occurred (1) in the operating room (76.3%), (2) <12 hours (10.9%), (3) 12 to 24 hours (7.2%), or (4) >24 hours (5.6%) after surgery. Hospitals in the top quartile for case volume had the highest percentage of patients extubated in the operating room (82.8%). Patients least likely to be extubated in the operating room were older, more likely to have chronic obstructive pulmonary disease, require vasopressors, have higher estimated blood loss (EBL), and longer procedure times. After adjustment for patient, procedure, and institutional factors, delayed extubation was associated with prolonged LOS (<12 hours: odds ratio [OR], 1.4; 95% confidence interval [CI], 1.2-1.7; 12-24 hours: OR, 2.1; 95% CI, 1.7-2.7; >24 hours: OR, 5.3; 95% CI, 4.0-6.9), and pulmonary complications (<12 hours: OR, 1.9; 95% CI, 1.4-2.6; 12-24 hours: OR, 2.6; 95% CI, 1.8-3.6; >24 hours: OR, 9.6; 95% CI, 7.1-13.0) compared with those extubated in the

operating room. Subset analysis of patients extubated in the operating room or <12 hours showed that extubation out of the operating room was associated with prolonged LOS (OR, 1.4; 95% CI, 1.2-1.7) and pulmonary complications (OR, 1.8; 95% CI, 1.3-2.5). The variable importance analysis demonstrated that EBL (26%) and procedure time (24%) accounted for half of the variation in extubation timing.

Conclusions: Extubation in the operating room is associated with shorter LOS and morbidity after open aortic surgery. EBL, procedure time, and center variation account for variability in extubation timing. These data advocate for standardized perioperative respiratory care to reduce variation, improve outcomes, and reduce LOS.

Implications of concomitant hypogastric artery embolization with endovascular repair of infrarenal abdominal aortic aneurysms

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Objective: Hypogastric artery embolization (HAE) is associated with significant risk of ischemic complications. We assessed the impact of HAE on 30-day outcomes of endovascular aneurysm repair (EVAR) of infrarenal abdominal aortic aneurysms.

Methods: We queried the American College of Surgeons National Surgical Quality Improvement Program database from 2011 to 2014 to identify and to compare clinical features, operative details, and 30-day outcomes of EVAR with those of concomitant HAE with EVAR (HAE + EVAR). Multivariate analysis was performed to determine preoperative and intraoperative factors associated with development of significant complications observed in patients with HAE + EVAR.

Results: In a cohort of 5881 patients, 387 (6.6%) underwent HAE + EVAR. Compared with EVAR, a higher incidence of ischemic colitis (2.6% vs 0.9%; $P = .002$), renal failure requiring dialysis (2.8% vs 1%; $P = .001$), pneumonia (2.6% vs 1.3%; $P = .039$), and perioperative blood transfusion (17% vs 13%; $P = .024$) was noted after HAE + EVAR. Thirty-day thromboembolic events, strokes, myocardial infarction, lower extremity ischemia, reoperation, and readmission rates were not significantly different ($P > .05$). Mortality at 30 days in HAE + EVAR patients was 4.1% compared with 2.5% with EVAR ($P = .044$). HAE was independently associated with increased risk of colonic ischemia (adjusted odds ratio, 2.98; 95% confidence

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interval, 1.44-6.14; $P = .003$) and renal failure requiring dialysis (adjusted odds ratio, 2.22; 95% confidence interval, 1.09-4.53; $P = .029$). However, HAE was not an independent predictor of mortality. Average length of hospital stay was 4 ± 8.5 days after HAE + EVAR vs 3.3 ± 5.9 days after EVAR ($P = .001$).

Conclusions: Concomitant HAE with EVAR is associated with longer and more complicated hospital stays. Ischemic colitis is a rare complication of EVAR. HAE increases the risk of ischemic colitis and renal failure requiring dialysis. This study highlights the importance of hypogastric artery preservation during EVAR.

The association of Carotid Revascularization Endarterectomy versus Stent Trial (CREST) and Centers for Medicare and Medicaid Services Carotid Guideline Publication on utilization and outcomes of carotid stenting among “high-risk” patients

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Objective: Since the 2004 approval by the United States Food and Drug Administration of carotid artery stenting (CAS), there have been two seminal publications about CAS reimbursement (Centers for Medicare and Medicaid Services guidelines; 2008) and clinical outcomes (Carotid Revascularization Endarterectomy versus Stent Trial [CREST]; 2010). We explored the association between these publications and national trends in CAS use among high-risk symptomatic patients.

Methods: The most recent congruent data sets of the Nationwide Inpatient Sample (NIS) were queried for patients undergoing carotid revascularization. The sample was limited to include only patients who were defined as “high-risk” if they had a Charlson Comorbidity Score of ≥ 3.0 . Subgroup analyses were performed of high-risk patients with symptomatic carotid stenosis. Utilization proportions of CAS were calculated quarterly from 2005 to 2011 for NIS. Three time intervals related to Centers for Medicare and Medicaid Services guidelines and CREST publication were selected: 2005 to 2008, 2008 to 2010, and after 2010. Logistic regression with piecewise linear trend for time was used to estimate different trends in CAS use for the overall high-risk sample and for neurologically asymptomatic and symptomatic cases. Multivariate logistic regression was used to compare odds of postoperative mortality and stroke between these two procedures at different time intervals independent of confounding variables.

Results: During the study period, 20,079 carotid endarterectomies (CEAs) and 3447 CAS procedures were performed in high-risk patients in the NIS database. CAS utilization constituted 20.5% of carotid revascularization procedures among high-risk symptomatic patients, with a significant increase from 18.6% to 24.4% during the study period ($P < .001$). There was an initial increase during 2005 to 2008

in the rate of CAS compared with CEA, CAS utilization significantly decreased during 2008 to 2010 by a 3.3% decline in the odds ratio (OR) of CAS per quarter (OR, 0.967; 95% confidence interval [CI], 0.943-0.993; $P = .002$), and after CREST (after 2010), CAS utilization continued to increase significantly from the prepublication to the postpublication time interval. The odds of in-hospital mortality (OR, 2.56; 95% CI, 1.17-5.62; $P = .019$) and postoperative in-hospital stroke (OR, 1.53; 95% CI, 1.09-3.68; $P = .024$) were independently and significantly higher for CAS patients in the overall sample.

Conclusions: The use of CAS for carotid revascularization in a high-risk cohort of patients has significantly increased from 2005 to 2011. Compared with CEA, CAS independently increased the odds of perioperative in-hospital stroke in all high-risk patients and of in-hospital mortality in symptomatic high-risk patients.

Outcomes of the Japanese multicenter Viabahn trial of endovascular stent grafting for superficial femoral artery lesions

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Objective: The objective of this study was to assess 1-year safety, efficacy, and invasiveness outcomes of endovascular stent grafting of symptomatic long lesions (≥ 10 cm) in the superficial femoral artery (SFA) as a substitute for above-knee open bypass surgery.

Methods: This prospective, multicenter (15 hospitals) study assessed heparin-coated stent grafts for the treatment of long SFA lesions in Japanese subjects with peripheral arterial disease. Inclusion criteria were Rutherford category 2 to 5 symptoms (grade 5 without active infection), ankle-brachial index ≤ 0.9 , and color flow duplex ultrasound-assessed SFA lesions with cumulative length ≥ 10 cm and $\geq 50\%$ stenosis. Main efficacy and safety outcomes were primary assisted patency and adverse events, respectively. Secondary outcomes included primary patency using the surgical bypass definition, that is, blood flow through a device without requiring target lesion revascularization (TLR) to maintain or to restore flow. For comparison with prior endovascular studies, primary patency-interventional was defined as peak systolic velocity ratio < 2.5 without TLR in treated lesions. Other outcomes included freedom from TLR and Vascular Quality of Life questionnaire scoring. General anesthesia avoidance and hospitalization duration were compared with historical data from 68 consecutive patients ($n = 51$ Rutherford 2/3 claudicants and 17 Rutherford 4/5 subjects) who underwent above-knee bypass surgery at study sites between 2002 and 2012 and met study enrollment criteria.

Results: Of 103 enrollees (74.2 ± 7.0 years old; 17.5% female; 97.1% claudicants), 100 subjects were evaluated through postoperative 12 months. Average lesion length was 21.8 ± 5.8 cm, and 65.7% were totally occluded. The

whole-cohort Kaplan-Meier estimated primary assisted patency rate was 94.1% (95% confidence interval [CI], 87.3%-97.3%) at 12 months. The primary patency-surgical rate was 92.1% (95% CI, 84.8%-96.0%), the primary patency-interventional rate was 88.1% (95% CI, 80.0%-93.1%), and freedom from TLR was 93.1% (95% CI, 86.1%-96.7%). Mean ankle-brachial index increased from 0.64 ± 0.12 to 0.98 ± 0.12 at 1 month after intervention and 0.94 ± 0.17 at 12 months ($P < .0001$ at both follow-ups). Target vessel revascularization, major amputation, or death did not occur through postoperative 30 days. No life- or limb-threatening intraoperative or perioperative adverse events and no acute limb ischemia cases were observed during follow-up. Vascular Quality of Life questionnaire score increased from $58.6\% \pm 15.7\%$ to $72.9\% \pm 18.6\%$ at 12 months ($P < .0001$). No stent fractures were detected. No stent graft participant required general anesthesia, and median postoperative hospital stay was 2.0 days (mean, 3.4 ± 2.9 days) in the Viabahn (W. L. Gore & Associates, Flagstaff, Ariz) claudicant subgroup, values that were significantly lower than the 76.5% general anesthesia rate ($P < .0001$) and 11.0 days median hospitalization stay (mean, 12.7 ± 5.3 days; $P < .0001$) in the 51 open bypass claudicant subjects.

Conclusions: Stent grafting appears to be a safe and less invasive alternative to above-knee bypass surgery, providing 88% to 92% primary patency at 12 months in long, complex lesions.

The LArgPAD Trial: Phase IIA evaluation of L-arginine infusion in patients with peripheral arterial disease

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Objective: Endothelial function is improved by L-arginine (L-arg) supplementation in preclinical and clinical studies of mildly diseased vasculature; however, endothelial function and responsiveness to L-arg in severely diseased arteries is not known. Our objective was to evaluate the acute effects of catheter-directed L-arg delivery in patients with chronic lower extremity ischemia secondary to peripheral arterial disease.

Methods: The study enrolled 22 patients (45% male) with peripheral arterial disease (mean age, 62 years) requiring lower extremity angiography. Endothelium-dependent relaxation of patent but atherosclerotic superficial femoral arteries was measured using a combination of intravascular ultrasound (IVUS) imaging and a Doppler FloWire (Volcano Corporation, Rancho Cordova, Calif) during the infusion of incremental acetylcholine (10^{-6} to 10^{-4} molar concentration) doses. Patients received 50 mg ($n = 3$), 100 mg ($n = 10$), or 500 mg ($n = 9$) L-arg intra-arterially, followed by repeat endothelium-dependent relaxation measurement (limb volumetric flow). IVUS-derived virtual histology of the culprit vessel was also obtained. Endothelium-independent relaxation was measured using a nitroglycerin infusion. Levels of nitrogen oxides and arginine metabolites were

measured by chemiluminescence and mass spectrometry, respectively.

Results: Patients tolerated limb L-arg infusion well. Serum arginine and ornithine levels increased by $43.6\% \pm 13.0\%$ and $23.2\% \pm 10.3\%$, respectively ($P < .005$), and serum nitrogen oxides increased by 85% ($P < .0001$) after L-arg infusion. Average vessel area increased by $6.8\% \pm 1.3\%$ with L-arg infusion (acetylcholine 10^{-4} ; $P < .0001$). Limb volumetric flow increased in all patients and was greater with L-arg supplementation by 130.9 ± 17.6 , 136.9 ± 18.6 , and 172.1 ± 24.8 mL/min, respectively, for each cohort. Maximal effects were seen with L-arg at 100 mg (32.8%). Arterial smooth muscle responsiveness to nitroglycerin was intact in all vessels (endothelium-independent relaxation, $137\% \pm 28\%$ volume flow increase). IVUS-derived virtual histology indicated plaque volume was 14 ± 1.3 mm³/cm, and plaque stratification revealed a predominantly fibrous morphology (46.4%; necrotic core, 28.4%; calcium, 17.4%; fibrolipid, 6.6%). Plaque morphology did not correlate with L-arg responsiveness.

Conclusions: Despite extensive atherosclerosis, endothelial function in diseased lower extremity human arteries can be enhanced by L-arg infusion secondary to increased nitric oxide bioactivity. Further studies of L-arg as a therapeutic modality in patients with endothelial dysfunction (ie, acute limb ischemia) are warranted.

Trends and outcomes in endovascular and open surgical treatment of visceral aneurysms

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Objective: Visceral artery aneurysms (VAAs) are rare but often repaired because of dire consequences of rupture. This is a population-based evaluation of chronologic trends in management, risk factors, and outcomes of endovascular and open therapy.

Methods: The 2003 to 2013 Agency for Healthcare Research and Quality (AHRQ) National Inpatient Sample (NIS) database was reviewed. Cases with primary diagnosis of VAA and undergoing endovascular or open repair were identified. Patients with renal artery or abdominal or thoracoabdominal aortic disease were excluded. Case numbers of respective techniques were charted over time. Baseline characteristics and in-hospital outcomes were compared for endovascular and open groups using χ^2 test, Fisher exact test, or *t*-test. Predictors of mortality and complications were evaluated with multivariate logistic regression.

Results: There were 9260 interventions for VAAs from 2003 to 2013, including 5166 endovascular and 4094 open. Endovascular repairs increased from 5.3 to 24.7 per 10 million U.S. population ($P < .001$), surpassing open repairs in 2008, which decreased from 14.3 to 9.2 per 10 million ($P < .001$). Endovascular patients were more likely to have been treated at urban teaching hospitals (77.1% vs 61.8%; $P < .0001$); to have higher proportions of renal failure

(7.6% vs 4.9%; $P = .02$), liver disease (11.3% vs 6.6%; $P < .001$), alcohol abuse (13.1% vs 3.6%; $P < .001$), chronic blood loss anemia (4.5% vs 1.6%; $P < .001$), metastatic cancer (2.7% vs 0.8%; $P = .003$), solid tumor without metastases (3.6% vs 2.0%; $P < .037$), and weight loss (9.8% vs 5.2%; $P < .001$); and less likely to have had elective admission (28.9% vs 59.8%; $P < .0001$). In-hospital mortality (4.1% vs 4.5%; $P = .618$) and overall complication rates (37.8% vs 38.8%; $P = .688$) were similar between groups; however, pulmonary complications were decreased for endovascular patients (10.6% vs 19.7%; $P < .001$). Endovascular patients had shorter hospital stays (6.5 vs 8.7 days; $P < .001$). Multivariate adjustment for mortality predictors, including coagulopathy (odds ratio [OR], 4.34; confidence interval [CI], 2.56-7.35; $P < .001$), liver disease (OR, 2.25; CI, 1.25-4.07; $P = .01$), fluid and electrolyte disorders (OR, 2.84; CI, 1.73-4.66; $P < .001$), and solid tumor without metastases (OR, 2.81; CI, 1.10-7.18; $P = .03$), showed that open treatment was associated with increased mortality (OR, 1.70; CI, 1.03-2.81; $P = .04$). Analysis of overall complications revealed that open treatment was again associated with increased complications (OR, 1.78; CI, 1.43-2.21; $P < .001$).

Conclusions: Endovascular VAA repairs are increasing. Despite patients' having worse comorbidities and more nonelective admissions, endovascular therapy appears to be associated with decreased mortality and complications and shorter hospital stays.

Characteristics of provoked deep venous thrombosis in a tertiary care center

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Objective: Provoked deep venous thrombosis (DVT) is precipitated by a specific event. This paper compares the characteristics of provoked DVT in patients with transient risk (TR) factors and patients with continuous risk (CR) factors.

Methods: A retrospective review of records of all consecutive patients diagnosed with DVT between January 2013 and August 2014 was performed. Patients with provoked DVT were included in the TR group if the provoking event resolved in 2 weeks and they did not have ongoing risk of thrombosis. Patients in the CR group had a provoked DVT with ongoing risk of thrombosis due to individual factors deemed to be ongoing risks of thrombosis, such as cancer, hypercoagulable disorder, and prolonged immobilization. Demographics, risk factors, association with pulmonary embolism (PE) and its severity, risk of recurrent venous thromboembolism (VTE), and mortality were compared between the two groups.

Results: A total of 838 patients were diagnosed with DVT, and 50.7% (425) were provoked. There were 127 (29.9%) patients with TR and 298 (70.1%) with CR. TR patients were

younger (60.4 ± 16.3 vs 65.9 ± 16.0 ; $P = .001$). TR was more likely to be provoked by surgery (70.9% vs 55.4%; $P = .003$), whereas CR was more likely to be provoked by immobilization (21.5% vs 12.6%; $P = .032$). CR patients were affected by cancer (48.7%) and hypercoagulable disorders (4.4%). TR patients were more likely to have calf DVTs (36.2% vs 26.2%; $P = .047$). There was a trend toward lower association with PE on presentation in TR (17.3% vs 21.1%; $P = .072$), but that did not reach statistical significance. However, TR factors were more likely to be associated with low-risk PE compared with CR factors (30.2% vs 54.6%; $P = .040$). After mean follow-up of 7.2 months, CR had higher risk of recurrent VTE (14.0% vs 6.8%; $P = .045$) and mortality (23.5% vs 7.1%; $P < .0001$).

Conclusions: Provoked DVT with CR factors affects older patients and is associated with high recurrence of VTE and mortality compared with provoked DVT with TR factors.

Clinical characteristics and prognostic features of intravenous leiomyomatosis with inferior vena cava or intracardiac extension

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Objective: The aim of this study was to explore the clinical characteristics and prognostic features of intravenous leiomyomatosis (IVL) with inferior vena cava extension (IVCE) or intracardiac extension (ICE).

Methods: A retrospective analysis was conducted of the clinical data of 38 patients with pathologically diagnosed IVL with IVCE or ICE.

Results: The mean age of the patients was 44.05 ± 6.31 years. Twenty-two patients (57.9%) had a history of uterine leiomyoma. Nine patients (23.7%) had a history of IVL without IVCE or ICE. The most common symptoms were chest tightness (seven patients), lower limb swelling (five patients), palpitation (four patients), dizziness (two patients), and abdominal distention (two patients). Preoperative diagnoses were achieved in 28 patients (73.7%); 23 patients (60.5%) underwent one-stage surgery, whereas 15 (39.5%) underwent two-stage surgery. Eighteen patients (72%) received postoperative antiestrogen hormone therapy. Regular follow-up was available in 30 patients, with a median follow-up time of 12.0 months; 15 patients (50.0%) showed evidence of recurrence. Factors such as postoperative antiestrogen hormone therapy (9/20 compared with 6/10; $P = .601$), duration of postoperative hormonal therapy (10/15 in >6 months compared with 5/15 in ≤ 6 months; $P = .862$), and heart involvement (10/22 compared with 5/8; $P = .669$) were not significantly associated with recurrence.

Conclusions: IVL with IVCE or ICE is a rare disease with nonspecific manifestations. Surgery is the primary treatment. The postoperative recurrence rate is high, and postoperative antiestrogen hormone therapy is not significantly correlated with recurrence.