

Selected Abstracts from the November Issue of the Journal of Vascular Surgery[☆]**Patterns of in-stent restenosis after carotid artery stenting: Classification and implications for long-term outcome**

B.K. Lal, E.A. Kaperonis, S. Cuadra, I. Kapadia and R.W. Hobson

Objectives. Factors predicting in-stent restenosis (ISR) and future need for target lesion revascularization (TLR) after carotid artery stenting (CAS) remain undetermined. We hypothesized that the patterns of restenotic lesions may provide prognostic information. In this study, we developed an ultrasound classification scheme for ISR based on lesion length and distribution and assessed factors that may predict the need for TLR.

Methods. Patients were followed up after CAS with B-mode ultrasound imaging, and ISR lesions ($\geq 40\%$ stenosis) were classified into type I (focal ≤ 10 mm end-stent lesions), II (focal ≤ 10 mm, intrastent), III (diffuse >10 mm, intrastent), IV (diffuse >10 mm proliferative, extending outside the stent), and V (total occlusion). The frequency of lesion types was assessed. Accuracy of the ultrasound classification was confirmed with angiography. We recorded patient (age, gender, comorbidities), lesion (severity, etiology, symptomatic status) and procedural features (type, number, length of stents), and the need for TLR.

Results. Eighty-five ISR lesions developed after 255 CAS procedures. Their percentage distribution was type I, 40; type II, 25.9; type III, 12.9; for type IV, 20; and type V, 1.2. Accuracy of the ultrasound classification was confirmed by angiography ($r^2 = 0.82$). Inter-rater agreement for the assignment of lesion type based on ultrasound was 0.88 (very good). TLR was performed in 13 that were $\geq 80\%$ diameter reducing. On univariate analysis, the need for TLR was highest in type IV lesions (0%, 0%, 27.3%, and 58.8% [types I to IV, respectively]; $P = .001$). History of ISR (2.9%, 0%, 0%, and 41.2% [types I to IV]; $P = .003$) and diabetes mellitus (20.6%, 22.7%, 45.5%, and 52.9% [types I to IV]; $P = .02$) occurred more frequently with type IV ISR lesions. On multivariate analysis of all patient, lesion, and procedural characteristics, only the type of ISR (odds ratio, 5.1) and a history of diabetes (odds ratio, 9.7) were independent predictors of TLR.

Conclusions. The proposed classification accurately grades the magnitude of intimal hyperplasia after CAS and provides important prognostic information. Diffuse proliferative (type IV) ISR lesions and diabetes are important determinants of long-term outcome after CAS. This classification will facilitate a standardized description of recurrence after CAS and enable early identification of high-risk patients for additional monitoring, treatment, and investigation.

Increased aortic arch calcification in patients older than 75 years: Implications for carotid artery stenting in elderly patients

H.A. Bazan, S. Pradhan, H. Mojibian, T. Kyriakides and A. Dardik

Objective. Recent studies reveal a consistently higher periprocedural risk of stroke during carotid artery stenting in octogenarians compared with younger patients. The mechanisms accounting for this increased risk of embolization and stroke in elderly patients are poorly understood. We analyzed the calcium content and aortic arch type in a consecutive series of patients to determine whether aortic arch calcium content is related to either age or arch type classification.

Methods. Aortic arch calcium content and arch classification were examined in consecutive patients undergoing thoracic computed tomography scans. The calcium content of the aortic arch, measured from the aortic root to the descending thoracic aorta at the level of the carina, was determined by using a coronary calcium score grade. The aortic arch classification was determined by using two-dimensional and multiplanar image reconstructions. Linear regression and analysis of variance were used to determine the effect of age, arch classification, and patient comorbidity on aortic arch calcium content.

Results. The computed tomography scans of 94 patients were analyzed. There was a positive correlation between age and aortic arch calcium content; the mean calcium score (Agatston units) for patients increased by decade (age < 50 years, 12.6 ± 12.3 , $n = 18$; age 50–59 years, 14.6 ± 8.2 , $n = 21$; age

60–69 years, 276 ± 120 , $n = 17$; age 70–79 years, 1382 ± 366 , $n = 27$; age ≥ 80 years, 3889 ± 778 , $n = 11$; $P < .001$). There was significantly more arch calcium in patients 75 years or older compared with patients younger than 75 years (2458 ± 447 vs 145 ± 49 ; $P < .001$). There was no effect of patient comorbidity on aortic arch calcium content. Patients with type II aortic arches were older and had a higher calcium content compared with patients with type I aortic arches (2028 ± 546 vs 712 ± 191 ; $P = .01$). Power analysis showed more than 99% power to detect differences between patients younger than 75 years and 75 years or older.

Conclusions. Patients 75 years of age or older have significantly more aortic arch calcification compared with younger patients. Increased arch calcium content and type II aortic arches may be markers of increased potential for embolization during endovascular manipulation that transverses the aortic arch. Preprocedural determination of aortic arch calcification and morphology may help to further stratify periprocedural carotid artery stenting risk in elderly patients.

Determinants of hypotension and bradycardia after carotid angioplasty and stenting

P.H. Lin, W. Zhou, P. Kougiyas, H.F. El Sayed, N.R. Barshes and T.T. Huynh

Background. Acute procedurally induced hemodynamic depression can occur after carotid angioplasty and stenting (CAS). This study was performed to determine the frequency and risk factors for hypotension and bradycardia after the CAS procedure.

Methods. The study reviewed clinical variables and angiographic data of all patients undergoing elective CAS with neuroprotection during a recent 5-year period. Intravenous atropine was given selectively in cases of bradycardia (heart rate < 60 beats/min or a decrease of > 20 beats/min). We further defined hemodynamic depression as bradycardia or severe hypotension (systolic blood pressure fall > 30 mm Hg). Frequency and potential risk factors for hemodynamic depression were analyzed by logistic regression.

Results. During the study period, 416 patients (99% male; mean age, 74 ± 11 years) underwent the CAS procedure. The median degree of stenosis was 93% (range, 60% to 99%). The frequencies of post-CAS hemodynamic depression include hypotension in 58 (14%), bradycardia in 112 (27%), or both in 21 (5%). All patients with bradycardia received intraprocedural atropine, and all heart rates returned to the baseline level. Persistent hypotension occurred in 45 patients (11%). Increased age was predictive for CAS-induced bradycardia or hypotension. Adjusted risk factors associated with hemodynamic depression include age > 78 years (odds ratio [OR], 5.25; 95% confidence interval [CI], 2.32 to 15.25; $P = .01$) and ejection fraction of $< 25\%$ (OR, 3.25; 95% CI, 0.58 to 6.58; $P = .02$). CEA-related restenosis was associated with a reduced risk of hemodynamic depression (OR, 0.21; 95% CI, 0.12 to 0.69, $P = .001$). Persistent hypotension after CAS was associated with an increased risk of an adverse clinical event (44%, $P = .001$).

Conclusions. Hemodynamic depression, including hypotension and bradycardia, is frequent after CAS. However, CAS-induced hemodynamic depression is rare in patients with postendarterectomy stenosis. Patients with compromised ejection fraction and increased age are at a higher risk of presenting with CAS-induced hemodynamic instability, and persistent hypotension after CAS is associated with an increased postprocedural complication rate.

Cost-effectiveness of conventional and endovascular repair of abdominal aortic aneurysms: Results of a randomized trial

M. Prinssen, E. Buskens, S.E. de Jong, J. Buth, A.J. Mackaay, M.R. Sambeek and J.D. Blankensteijn for the DREAM trial participants

Background. Two randomized trials have shown similar mid-term outcomes for survival and quality of life after endovascular and conventional open repair of abdominal aortic aneurysms (AAA). With reduced hospital and intensive care stay, endovascular repair has been hypothesized to be more efficient than open repair. The Dutch Randomized Endovascular Aneurysm

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Management (DREAM) trial was undertaken to assess the balance of costs and effects of endovascular vs open aneurysm repair.

Methods. We conducted a multicenter, randomized trial comparing endovascular repair with open repair in 351 patients with an AAA and studied costs, cost-effectiveness, and clinical outcome 1 year after surgery. In addition to clinical outcome, costs and quality of life were recorded up to 1 year in 170 patients in the endovascular repair group and in 170 in the open repair group. Incremental cost-effectiveness ratios were estimated for cost per life-year, event-free life-year, and quality adjusted life-year (QALY) gained. Uncertainty regarding these outcomes was assessed using bootstrapping.

Results. Patients in the endovascular repair group experienced 0.72 QALY vs 0.73 in the open repair group (absolute difference, 0.01; 95% confidence interval [CI], -0.038 to 0.058). Endovascular repair was associated with additional €4293 direct costs (€18,179 vs €13,886; 95% CI, €2,770 to €5,830). Most of the bootstrap estimates indicated that endovascular repair resulted in slightly longer overall and event-free survival associated with respective incremental cost-effectiveness ratios of €76,100 and €171,500 per year gained. Open repair appeared the dominant strategy in costs per QALY.

Conclusion. Presently, routine use of endovascular repair in patients also eligible for open repair does not result in a QALY gain at 1 year postoperatively, provides only a marginal overall survival benefit, and is associated with a substantial, if not prohibitive, increase in costs.

Dynamic geometry and wall thickness of the aortic neck of abdominal aortic aneurysms with intravascular ultrasonography

F.R. Arko, E.H. Murphy, C.M. Davis III, E.D. Johnson, S.T. Smith and C.K. Zarins

Background. It is commonly assumed that the aortic wall deforms uniformly and has uniform wall thickness about the circumference. The purpose of this study was to evaluate the aortic wall motion and thickness in the infrarenal aortic neck of patients with abdominal aortic aneurysms who were undergoing endovascular repair (EVAR) and to compare the dynamic measurements of intravascular ultrasonography with the static measurements of computed tomographic angiography (CTA).

Methods. A total of 25 patients were evaluated before surgery with CTA and three-dimensional reconstructions on a Vitrea workstation, followed by intraoperative assessment of the proximal aortic neck with intravascular ultrasonography (IVUS) before EVAR. Infrarenal aortic neck dimensions on CTA were obtained at 1-mm intervals, but for the purposes of this study all dimensions on CTA were obtained 1 cm below the lowest renal artery. IVUS analysis of the proximal aortic neck was obtained with a 10-second recorded data loop of aortic wall motion. A Digital Imaging and Communications in Medicine viewer was used to view the recorded loop of aortic movement, and each image was captured and then evaluated with a SCION PCI Frame Grabber to determine aortic dimensions and wall thickness. IVUS diameters (250 measurements of each aorta) were recorded through a full continuous cardiac cycle from the epicenter of the lumen (maintaining the left renal vein in its normal anatomic configuration) in an anteroposterior (AP) direction in the area of greatest wall movement and 90° perpendicular to this direction (lateral movement).

Results. There was significant variation in infrarenal aortic wall movement about the circumference, with 1.7 ± 0.6 mm (range, 0.6–2.7 mm) displacement in the AP direction and 0.9 ± 0.5 mm (range, 0.3–1.5 mm) displacement in the lateral direction ($P < .001$). Aortic wall thickness was greater in the region of increased AP wall motion than in the area of lesser lateral wall motion (2.3 ± 0.6 mm vs 1.2 ± 0.3 mm; $P < .001$). There was no difference between the IVUS and CTA aortic neck measurements (25.5 vs 25.6 mm; not significant) during the midpoint of the cardiac cycle of IVUS. However, at peak systole, IVUS recorded a greater diameter than CTA (26.4 vs 25.6 mm; $P < .001$), and at end-diastole, IVUS recorded a smaller diameter than CTA (24.7 vs 25.6 mm; $P = .01$).

Conclusions. The infrarenal neck of aortic aneurysms deforms anisotropically during the cardiac cycle. The greatest displacement is in the AP direction and corresponds with a significantly greater wall thickness in this area. The magnitude of cyclic change in aortic diameter can be as high as 11%. Further evaluation of proximal aortic neck wall motion after EVAR is warranted to determine the interaction of various stent designs and the aortic wall.

Endovascular management of acute blunt traumatic thoracic aortic injury: A single center experience

C.L. Bent, M.B. Matson, M. Sobeh, I. Renfrew, R. Uppal, M. Walsh, K. Brohi and C. Kyriakides

Background. Traumatic injury of the thoracic aorta is a life-threatening complication in patients who sustain deceleration or crush injuries. The magnitude of force necessary to cause blunt thoracic aortic injury results in a high proportion of concomitant injuries, posing a significant challenge for prioritizing management. Open surgical mortality is increased in the presence of coexisting head, lung, and abdominal injuries. Spinal cord ischemia may occur following aortic cross-clamping and operative hypotension. Endovascular stent-graft placement offers a safe, effective, and timely treatment option. The aim of this study was to assess our single center experience of endovascular repair following acute blunt traumatic aortic injury.

Methods. Data from thirteen consecutive patients (mean age, 43.2 years; range, 16 to 84 years) with acute blunt traumatic aortic injury treated by endovascular stent-graft insertion between October 2001 and March 2007 was prospectively collected. Demographics, injury characteristics, technique, and complications were recorded. Follow-up data consisted of computed tomographic angiography and plain chest radiography at regular intervals. Mean and median follow-up after stent-graft implantation were 28.9 and 29 months, respectively.

Results. All patients underwent endovascular repair within a median of 9 hours from hospital presentation. Two patients underwent carotico-carotid bypass immediately prior to endovascular stenting during a single anesthetic. Stent-graft implantation was technically successful in all patients. No patient required conversion to open surgical repair of the acute blunt traumatic aortic injury. Procedure-related paraplegia was zero. Complications included proximal migration of initial stent-graft in one patient and iliac artery avulsion in another patient with consequent ilio-femoral bypass. The median hospital stay was 17 days. There were no in-hospital deaths.

Conclusion. Endovascular repair is evolving as the procedure of choice for acute blunt traumatic aortic injury. Treatment of lesions that extend into the aortic arch is feasible with extra-anatomical bypass. In our study, endovascular repair of blunt traumatic aortic injury is a safe procedure with low morbidity and a mortality rate of zero.

Impact of diabetes mellitus on outcomes of superficial femoral artery endoluminal interventions

A.M. Bakken, E. Palchik, J.P. Hart, J.M. Rhodes, W.E. Saad and M.G. Davies

Background. Although aggressive endoluminal therapy for superficial femoral artery (SFA) occlusive disease is commonplace, the implications of diabetes mellitus (DM) on long-term outcomes in this population are unclear. We examined the consequences of endovascular treatment of the SFA in patients with and without DM.

Methods. A database of patients undergoing endovascular treatment of the SFA between 1986 and 2005 was maintained. Three groups were defined: nondiabetic patients, those with non-insulin-dependent DM (NIDDM), and those with insulin-dependent DM (IDDM). Intention-to-treat analysis was performed. Results were standardized to TransAtlantic Inter-Society Consensus (TASC) and Society for Vascular Surgery criteria. Time-dependent outcomes were assessed with Kaplan-Meier survival analyses. Factor analyses were performed using a Cox proportional hazard model for time-dependent variables. Data are presented as mean \pm SD where appropriate.

Results. Endovascular treatment (ie, balloon angioplasty \pm adjuvant stenting in 38%) was initiated in 525 limbs in 437 patients (68% male; average age, 66 ± 14 years) for claudication failing conservative therapy or chronic critical limb ischemia (CLI). Of these, 50% were nondiabetic, 26% had NIDDM, and 24% had IDDM. Analyses were separated by those presenting with claudication (61%) and those presenting with CLI (39%). Among patients presenting with claudication, those with IDDM had significantly lower assisted primary patency ($P < .01$) and a higher incidence of restenosis ($P = .04$). Patencies at 3 years for nondiabetic, NIDDM, and IDDM were 62%, 72%, and 54% (primary), and 81%, 86%, and 65% (assisted primary), respectively. Patency and restenosis rates were associated with lesion calcification, TASC D lesion categorization, and acute periprocedural occlusion. Among patients presenting with CLI, patency and restenosis rates were equivalent across all groups;

however, limb salvage was significantly worse for both groups of diabetic patients compared with nondiabetic (NIDDM, $P = .01$; IDDM, $P = .02$). Reduction in limb salvage rates was associated with presence of tissue loss at presentation, end-stage renal disease, and progression of distal disease on follow-up.

Conclusions. Endoluminal therapy for SFA occlusive disease yields lower assisted patency rates and higher restenosis rates for those patients presenting with claudication who have more advanced diabetes (ie, IDDM). Among those patients presenting with CLI, particularly those with tissue loss, limb salvage rates are lowered for the diabetic groups (NIDDM and IDDM) despite equivalent patency and restenosis rates.

Stenting of the venous outflow in chronic venous disease: Long-term stent-related outcome, clinical, and hemodynamic result

P. Neglén, K.C. Hollis, J. Olivier and S. Raju

Background. Stenting of chronic nonmalignant obstruction in the venous outflow tract started in earnest in 1997. Data sets are now available to perform long-term analysis of stent-related outcome and clinical and hemodynamic results of this intervention.

Materials. From 1997 to 2005, 982 chronic nonmalignant obstructive lesions of the femoroiliocaval vein were stented under intravascular ultrasound guidance. Median patient age was 54 years (range, 14 to 90 years), the female/male was 2.6:1, and left/right limb symptoms, 2.4:1. Clinical score of CEAP was 2 in 7%, 3 in 47%, 4 in 24%, 5 in 5%, and 6 in 17%; primary/secondary etiology was 518:464. Stent-related outcome (morbidity, thrombotic events, patency, in-stent recurrent stenosis), clinical outcome, quality of life (QOL) as assessed by the Chronic Venous Insufficiency Quality of Life

Questionnaire (CIVIQ), and hemodynamics were evaluated before and after intervention.

Result. Monitoring for 94% of patients lasted a mean 22 months (range, 1 to 107 months). Stenting was performed with no mortality (<30 days) and low morbidity. Thrombotic events were rare (1.5%) during the postoperative period (<30 days) and during later follow-up (3%). At 72 months, primary, assisted-primary, and secondary cumulative patency rates were 79%, 100%, and 100% in nonthrombotic disease and 57%, 80%, and 86% in thrombotic disease, respectively. Cumulative rate of severe in-stent restenosis (>50%) occurred in 5% of limbs at 72 months (10% in thrombotic limbs, 1% in nonthrombotic limbs). The main risk factors associated with stent occlusion were the presence and severity of thrombotic disease; thrombophilia by itself was not a risk factor. The median pain score and degree of swelling decreased significantly poststent. Severe leg pain (visual analogue scale >5) and leg swelling (grade 3) decreased from 54% and 44% pre-stent to 11% and 18% poststent, respectively. At 6 years, cumulative rates of complete relief of pain and swelling were 62% and 32%, respectively, and ulcer healing was 58%. The mean CIVIQ scores of QOL improved significantly in all categories. Mean hand-foot pressure differential decreased and mean ambulatory venous pressure improved in stented limbs with no concomitant reflux. The hemodynamic response was modified, depending on the presence of deep and superficial reflux in subsets of patients with adjunct saphenous procedures. No increase in venous reflux was observed.

Conclusions. Venous stenting can be performed with low morbidity and mortality, long-term high patency rate, and a low rate of in-stent restenosis. It resulted in major symptom relief in patients with chronic venous disease, which was not consistently reflected in any substantial hemodynamic improvement by conventional measurements. The beneficial clinical outcome occurred regardless of presence of remaining reflux, adjunct saphenous procedures, or etiology of obstruction.