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Carotid Stenting Is Inferior to Carotid Endarterectomy in the Low Physiologic Risk Population: Results of the National Inpatient Sample, 2004-7

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Objective: The SAPPHIRE trial established that carotid artery stenting (CAS) is not inferior to carotid endarterectomy (CEA) for patients at high surgical risk. The CREST trial has shown CEA has a lower stroke rate than CAS, at the expense of higher cardiac complications. The objective of this study was to evaluate the nationwide performance of CAS and CEA in both high-risk (HR) and low-physiologic-risk (LR) patients, outside of the clinical trial setting.

Methods: Data from the National Inpatient Sample (NIS) were pooled for patients undergoing carotid intervention from 2004-2007. HR was defined as preexisting cardiac disease (CHF, valvular disease) or COPD. Stroke, death, myocardial infarction, and complication rates were determined in both HR and LR populations. Multivariate regression analysis was performed to determine adjusted odds of stroke and death.

Results: From 2004-2007, CEA was performed in 490,665 patients (HR, 30.6%) and CAS in 50,283 patients (HR, 31.2%). Unadjusted stroke/death rates were higher for CAS vs CEA in both HR and LR groups (Table). Myocardial infarction rates were equivalent in the HR population and slightly higher for CAS in the LR population. Combined complication rates were higher after CEA vs CAS, mainly due to pulmonary and renal complications. Multivariate regression analysis revealed adjusted odds of stroke/death were increased for CAS (OR, 1.36; CI, 1.28-1.45). HR patients had an equivalent odds of stroke/death after CAS (OR, 1.10; CI, 0.99-1.28), whereas LR patients had an increased odds (OR, 1.56; CI, 1.45-1.67).

Conclusions: This nationwide, real-world study supports the use of CAS in the HR population undergoing carotid intervention. However, the LR population is at higher risk of stroke and death after CAS compared with CEA. Contrary to the CREST results, both carotid procedures can be performed with equivalent cardiac morbidity.

EEG Monitoring with SSEP Obviates Need for Shunting in CEA, even with Stroke

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Objective: The utilization of selective cerebral shunting during carotid endarterectomy (CEA) has been predicated on surrogate measures such as contralateral carotid occlusion, back-pressure measurements, and the patient's motor and cognitive function with regional anesthesia or recent stroke. This study analyzed the need for shunting in CEA where comprehensive electroencephalography (EEG) monitoring with somatosensory evoked potentials (SSEP) was the sole determinant of the necessity of a shunt.

Design: A retrospective review was performed in a single institution of all consecutive CEAs performed between September 2002 and March 2010. The decision for carotid shunting was based only on changes in continuous EEG dynamics reflecting ischemia as assessed intraoperatively by a neurologist. SSEP were used in a portion of cases as a functional confirmation of EEG findings. No other factor influenced the need for a shunt. Patient demographics, including age, degree of internal carotid artery (ICA) stenosis, preoperative neurologic symptoms, and medications were reviewed. Thirty-day outcomes, including stroke, TIA, death, and other major complications were tabulated.

Results: A total of 163 patients (100 [62.5%] men; mean age 69.4 years, [range, 44-91]) underwent 169 carotid endarterectomies. Of the total arteries treated, 76 (45%) were symptomatic, of which 66 (39%) had a documented stroke. A total of 20 patients (11.8%) had high-grade contralateral (80%-99%) ICA stenosis and 12 (7%) had contralateral ICA occlusion. Only two shunts (1.2%) were used. The 30-day stroke, TIA, death rates were four (2.3%), zero (0%), and two (1.2%), respectively. There was one intraoperative stroke and the other three strokes occurred ≤30 days. None of the patients with contralateral occlusion or contralateral high-grade ICA stenosis had EEG changes necessitating a shunt.

Conclusion: Continuous EEG monitoring with SSEP dramatically reduces the need to place a shunt during CEA. Recent stroke, contralateral ICA occlusion, or contralateral high-grade ICA stenosis are not an indication for intraoperative shunting. Shunting for CEA should be vanishingly rare. EEG with SSEP should be considered the gold standard for monitoring of cerebral perfusion during CEA.

Spatial Distribution of Microemboli Following Carotid Interventions

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Background: Despite the absence of clinically evident neurologic symptoms, subclinical microemboli during carotid interventions are common. Characterizing the typical locations of these lesions is an important step in identifying neural systems vulnerable to disruption. The purpose of this study was to examine the distribution of microemboli after carotid interventions using a novel imaging analysis program.

Methods: Patients who received both preoperative and postoperative MRI evaluations for carotid interventions at a single academic institution from 2002 to 2008 were retrospectively evaluated. Microemboli were defined by new hyperintensities on postoperative diffusion-weighted MRI sequence (DWI) with corresponding decreased diffusion on the ADC map. Microemboli regions of interest (ROI) were manually defined (MRICron) and normalized using SPM5 along with ADC images. ROIs were smoothed using a conservative Gaussian distribution (FWHM = 6 mm) with FSL and input to a modified version of the Anatomic Likelihood Analysis (ALE) algorithm, in which a voxel-wise statistic was computed to derive a measure of agreement across images.

Results: Inter-rater reliability was first established between a board-certified neuroradiologist with experience detecting microemboli and a novice rater trained to adequate inter-rater reliability with respect to microembolus volume (R^2 = 0.99) and spatial overlap (similarity index = 0.80). Among 160 patients who underwent carotid interventions and received both preoperative and postoperative MRI studies, 81 had new postoperative DWI lesions. Areas with a high degree of convergence across ROIs included the anterior and posterior cingulate, middle frontal gyrus, insula, basal ganglia, and occipital areas (Brodmann areas 18 and 19; Fig).

Conclusion: Regions vulnerable to microemboli include those implicated in executive control and motor planning/speeded responses (anterior

Table. Chi-square analysis of carotid interventions

	High risk (165,741)			*Low risk (375,207)*		
Outcome, % (No.)	*CEA (150,053)*	*CAS (15,688)*	P	*CEA (340,612)*	*CAS(34,595)*	P
Stroke/death	4.60 (6908)	6.14 (964)	<.001	3.61 (12,286)	5.91 (2.044)	<.001
Stroke/death/MI	7.84 (11,765)	8.99 (1,410)	<.001	5.52 (18,797)	8.27 (2861)	<.001
Complications						
MI	3.61 (5416)	3.45 (541)	.312	2.06 (7.012)	2.66 (921)	<.001
Pulmonary	3.02 (4529)	1.01 (158)	<.001	1.04 (3540)	0.39 (136)	<.001
Renal	0.73 (1092)	0.41 (65)	<.001	0.72 (2437)	0.16 (54)	<.001
Combined	6.56 (9838)	4.52 (709)	<.001	3.56 (12,121)	3.12 (1081)	<.001

cingulate, middle frontal gyrus, basal ganglia) and memory (posterior cingulate). This finding forms a basis of selecting an appropriate set neuropsychologic battery to accurately evaluate cognitive effects of microemboli.

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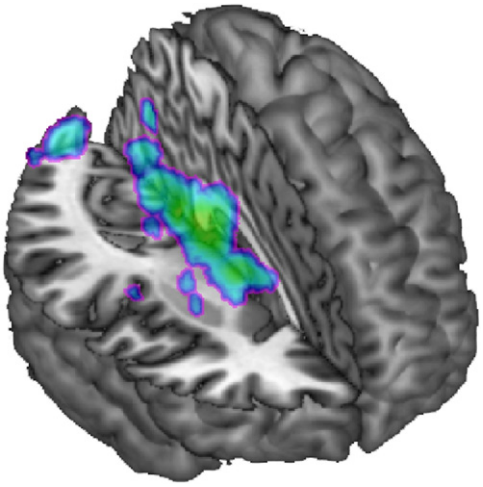

Fig. Regions vulnerable to microemboli

Contemporary Management of Aberrant Right Subclavian Arteries

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Background: Aberrant origin of right subclavian arteries represents the most common of the aortic arch anomalies. This variant has few published series to guide management. Our goal was to review treatment options and results for these potentially complex reconstructions.

Methods: A retrospective review was performed on all patients with the diagnosis of aberrant right subclavian artery at our institution from January 2003 through July 2009.

Results: Nineteen patients, comprising one of the largest series reported, including 9 males and 10 females (mean age, 40.6 years; range, 7-77), were diagnosed with an aberrant right subclavian artery. The diagnosis was incidental in 14 (74%), but 5 (26%) had symptoms of dysphagia or upper extremity ischemia, or both. The diagnosis was established by computed tomography in 15 patients (79%), by magnetic resonance imaging in 3 (15%), and by standard angiography in 1 (5%). The most common associated anomaly was a Kommerell's diverticulum (KD), which was found in five patients (26%), all of whom required intervention for symptoms or aneurysmal degeneration. Intervention was performed in 10 patients (53%), including carotid subclavian bypass in 5 (50%), carotid subclavian transposition in 3 (30%), and ascending aorta to subclavian bypass in 2 (20%). Four patients (40%) had additional intervention for management of aneurysmal disease of the aorta or KD, with open aortic replacement in two (20%) and aortic endografting in two (20%). There was one perioperative death (10%) in a patient undergoing aortic arch debranching with placement of an aortic endograft. Eighteen patients were alive without symptoms after a mean follow-up of 38 months.

Conclusions: Aberrant right subclavian arteries are most commonly found incidentally with computed tomography. The presence of a KD appeared to correlate with the need for intervention. Patients with no symptoms with the absence of a KD can safely be followed.

Clinical Outcomes and Implications of Failed Infrainguinal Endovascular Stents

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Objective: Although the influence of initial TASC II classification has been clearly shown to influence the primary patency of infrainguinal stenting procedures, its effect on outcomes once stent failure has occurred is less well documented. It is the objective of this paper to determine whether clinical outcomes and implications of anatomic stent failure vary according to initial TASC II classification

Methods: Results were analyzed by TASC II classification. Kaplan-Meier survival curves were plotted, and differences between groups tested by log-rank method. A Cox proportional hazards regression model was used to perform the multivariate analysis

Results: During a 5-year period, 239 angioplasties and stents were performed in 192 patients. Primary patency was lost in 69 stented arteries. Failure was due to one or more hemodynamically significant stenoses in 43 patients and occlusion in 26. After primary stenting, limbs initially classified as TASC C and D were more likely to fail with occlusion ($P < .0001$), require open operation ($P = .032$), or lose runoff vessels ($P = .0034$) than those classified as TASC A or B. In two patients initially classified as TASC C, stent failure changed the level of the open operation to a more distal site. Percutaneous reintervention was performed on 35 limbs. Successful reintervention improved the patency of TASC A and B lesions to 92%, 85%, and 64% and TASC C and D lesions to 78%, 72%, and 50% at 12, 24, and 36 months, respectively. Initial TASC classification was highly predictive of first anatomic failure ($P < .0001$) but did not predict the durability of subsequent catheter based reintervention ($P = .32$). Ten patients with stent failure required operation, and five underwent amputation; all had failed with occlusion. Overall limb salvage was 89% and periprocedural mortality was 0.4%.

Conclusions: After primary stenting of the SFA and popliteal artery, lesions classified as TASC C or D are more likely to fail with occlusion, lose runoff vessels, and alter the site of subsequent open operation than their TASC A and B counterparts. Although these complications are infrequent, they may negatively impact later attempts at revascularization and this must be considered when deciding on the proper treatment strategy for patients with infrainguinal occlusive disease.

Intraoperative Thrombolysis and Laser Atherectomy: Effective Treatment for TASC C and D Lesions in Critical Limb Ischemia

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Objective: We postulate that catheter-directed intraoperative thrombolysis in conjunction with laser atherectomy is a safe and effective treatment of TASC C and D critical limb ischemia.

Methods: We retrospectively analyzed 411 patients who underwent 670 percutaneous, lower extremity interventions from September 2004 to October 2009. Indications for intervention were limb salvage (98.7%) and claudication (1.3%). TASC C lesions were present in 40.9% of patients and TASC D lesions in 59.1%. Gender was 51.0% male and 49.0% female. Average age was 69.5 ± 12.0 years (range, 30-97 years). Risk factors included hypertension (87.8%), diabetes (70.2%), coronary artery disease (56.4%), tobacco abuse (54.8%), hyperlipidemia (49.4%), COPD (36.6%), congestive heart failure (26.3%), renal insufficiency (23.7%), history of myocardial infarction (21.3%), history of TIA or CVA (20.0%), atrial fibrillation (16.6%), dialysis (16.0%), morbid obesity (14.9%), arrhythmia (7.3%), and pacemaker (6.1%). All procedures involved catheter-directed arterial infusion of 2 to 10 mg of tissue plasminogen activator into the lesion and laser atherectomy: 647 extremities required balloon angioplasty, and 326 extremities required stenting. Technical success required completion of the intended procedure. Clinical success required no deaths, strokes, myocardial infarctions, bleeding requiring transfusion, thromboemboli, infection, respiratory complications, or reinterventions within 30 days. Follow-up was at 24 hours, 30 days, 6 months, and then every 6 months. Kaplan-Meier analysis was used for patency, limb salvage, and survival rates.

Table. Patency, limb salvage, and survival rates

	1 Mon (%)	*3 Mon (%)*	*6 Mon (%)*	*12 Mon (%)*	*24 Mon (%)*	*48 Mon (%)*
Primary	89.5	79.6	66.4	50.4	43.3	26.5
Primary assisted	91.5	82.2	71.0	59.3	51.7	35.8
Secondary	94.9	90.0	84.3	82.6	78.0	71.2
Limb salvage	96.3	92.7	88.7	86.7	81.3	74.5
Survival	96.7	89.9	86.1	78.6	69.9	62.4