A Stroke/Vascular Neurology Service Increases the Volume of Urgent Carotid Endarterectomies Performed in a Tertiary Referral Center

Hernan A. Bazan, Gentry Caton, Shahrzad Talebinejad, Ross Hoffman, Taylor A. Smith, Gabriel Vidal, Kenneth Gaines, and W. Charles Sternbergh III, New Orleans, Louisiana

Background: Increasing evidence supports that urgent carotid endarterectomy (CEA), defined as CEA during the index hospitalization, may be undertaken in select patients with acute carotid-related neurologic symptoms to prevent recurrent ischemic events. We aimed to determine the effect of a stroke/vascular neurology service on the volume of urgent CEAs performed and assess perioperative outcomes.

Methods: A retrospective review from a single tertiary referral center between June 2005 through December 2011 revealed 393 patients who underwent CEA. We identified the number of urgent CEAs before (June 2005−August 2008) and after (September 2008−December 2011) a stroke/vascular neurology service was implemented, as well as asymptomatic CEAs and symptomatic but electively performed CEAs. Demographic data as well as 30-day adverse outcomes (transient ischemic attack [TIA], stroke, myocardial infarction, and mortality) were analyzed for each group. In patients undergoing urgent CEA, TIA and stroke severity were assessed by a stroke neurologist using the $ABCD^2$ TIA score and National Institutes of Health Stroke Scale (NIHSS), respectively. The χ^2 test was used to compare differences between the urgent CEA volume before and after a stroke/vascular neurology service. Fisher's exact test was used to analyze perioperative outcomes.

Results: Demographics and comorbidities were similar between the 2 groups. The proportion of urgent CEAs performed increased significantly after initiation of a vascular neurology service (4.1% [7 of 172] vs. 22.2% [49 of 221], $P < 0.0001$). Per annum, urgent CEAs increased from 5.3% (4/75) in 2005 to 39.6% (25/63) in 2011. A vascular neurology service did not increase the number of nonurgent referrals. Urgent CEA indications were ocular ischemic events 4% (2/49), cerebral ischemic/infarction events 35% (17/49), crescendo TIAs 6% (3/49), acute stroke 45% (22/49), and stroke-in-evolution 10% (5/49). Mean NIHSS was 3.5 (range 0−24); mean TIA score was 5 (range 1−8). Although there were no statistical differences in 30-day outcomes, there was a trend toward a higher combined complication rate (stroke, death, myocardial infarction) in the urgent compared with the symptomatic but electively performed CEA group (7.1 % [3/49] vs. 2% [1/49]; $P = .36$). However, patients undergoing urgent CEA with an NIHSS <10 had no perioperative complications.

Conclusions: Collaboration with a vascular neurology team increased the volume of urgent CEAs over a 3-year period. In patients with mild-to-moderate strokes (NIHSS <10), urgent CEA perioperative outcomes approximate those for electively performed CEAs, suggesting improved care through a multidisciplinary approach.

Section of Vascular/Endovascular Surgery, Department of Surgery and Vascular Neurology Service, and Department of Neurology, Ochsner Clinic, New Orleans, LA.

Correspondence to: Hernan A. Bazan, MD, FACS, Ochsner Clinic, 1514 Jefferson Highway, 8th Floor, New Orleans, LA 70121, USA; E-mail: hbazan@ochsner.org

Ann Vasc Surg 2014; 28: 1172–1177
http://dx.doi.org/10.1016/j.avsg.2013.10.002

Manuscript received: April 13, 2013; manuscript accepted: October 6, 2013; published online: March 22, 2014

INTRODUCTION

Patients presenting with acute carotid-related neurologic symptoms are at a heightened risk of a stroke.[1] Natural history data suggests that the risk of stroke after a transient ischemic attack (TIA) is 6.7% at 2 days and up to 11.7% at 7 days.[2] This significant stroke rate was found in patients presenting with TIAs aged over 60 years, hypertensive patients, diabetics, and those experiencing unilateral weakness for 60 minutes or more. Several groups have thus advocated for carotid endarterectomy (CEA) during the index hospitalization (urgent CEA) in select patients with acute neurologic symptoms to minimize the risk of recurrent ipsilateral cerebral ischemic events.[3–7] Moreover, a subset of patients with few comorbidities undergoing urgent CEA were found to have low rates of perioperative complications.[8]

The effect of rapid-access TIA clinics on procedures performed and outcomes has been recently described.[9,10] Implementation of a 24-hour TIA clinic in France led to earlier medical optimization and identified a subset of patients (5%) who underwent urgent CEA.[9] Moreover, the expected 90-day stroke rate was reduced from 5.96% to 1.24%, based on predicted $ABCD^2$ TIA scores. In the United Kingdom, Naylor and colleagues recently demonstrated that establishment of a TIA clinic led to decreased delays in referral to CEA from the index ischemic event from 9 to 4 days.[10]

However, the effects of a dedicated stroke/vascular neurology service on the inpatient management of patients presenting with acute carotid-related events has not been described. Because the majority of patients with acute neurologic symptoms present acutely to the emergency department, the inpatient management of such patients through coordinated service lines is important. We sought to determine whether a dedicated stroke/vascular neurology service increases the volume of urgent CEAs performed in a tertiary referral center and assess perioperative outcomes.

METHODS

All CEA procedures performed for asymptomatic and symptomatic carotid stenosis at the Ochsner Clinic in New Orleans, Louisiana, between June 1, 2005 and December 31, 2011 were retrospectively reviewed after obtaining institutional review board approval. Symptomatic but electively performed CEA patients were defined as those presenting with an ocular ischemic events, cerebral TIAs, or stroke within 6 months.

Urgent CEA patients were defined as those with recent (<10 days) ischemic symptoms who underwent CEA during the same (index) hospitalization after admission through the emergency department, from another hospital through the regional transfer center, or the stroke telemedicine program. Select patients presenting within 4 hours of the ischemic event who were deemed by the vascular neurologist to have an acutely ischemic middle cerebral artery or branch artery event were administered intravenous thrombolysis (tissue plasminogen activator, 0.9 mg/kg; 10% bolus over 1 minute followed by 90% infusion over 60 minutes). For patients undergoing urgent CEAs presenting with TIAs, an $ABCD^2$ TIA score was recorded.[11] In brief, the $ABCD^2$ score predicts risk of stroke at 2, 7 and 90 days based on the number severity of score (1–7; score of 0–3 has a 7-day risk of stroke of 1.2%, whereas a score of 6–7 has a 7-day risk of stroke of 11.7%). Variables that make up the $ABCD^2$ score are age >60 years, systolic blood pressure >140 mm Hg, the presence of unilateral weakness or speech impairment, duration of TIA 10 to 59 minutes versus >60 minutes, and the presence of diabetes. The National Institutes of Health Stroke Scale (NIHSS) was used to quantify stroke severity in patients presenting with a stroke. The NIHSS is a clinical stroke assessment tool to evaluate and report neurologic status in patients with acute strokes; it can predict lesion size and serve as a measure of stroke severity (www.nihstrokescale.org/). NIHSS score of 1 to 4 is a ''minor stroke,'' 5 to 15 a ''moderate stroke,'' 16 to 20 a ''moderate to severe stroke,'' and 21 to 42 a ''severe stroke.''

All patients underwent preoperative bilateral carotid duplex ultrasound and/or computed tomography angiography of the neck and found to have ≥50% carotid stenosis North American Symptomatic Carotid Endarterectomy Trial (NASCET criteria) ipsilateral to the ischemic event, depending on physician preference. Noncontrast computed tomography head scan and magnetic resonance imaging were obtained according to physician preference, depending on the severity of symptoms. Mono- or dual-antiplatelet therapy (aspirin 81 or 325 mg; clopidogrel 75 mg), depending on physician preference, was initiated with high-dose statin therapy (simvastatin 80 mg). A clinical pathway has been established with the vascular neurology service such that all acutely symptomatic carotids are referred by the vascular neurology service/''stroke central'' to vascular surgery for possible CEA. In cases involving medically high-risk patients, such as chronic obstructive pulmonary disease (COPD) with home oxygen dependence, judged by 1 of the vascular

surgeons to have an unacceptable risk for CEA, carotid artery stent (CAS) with proximal protection or embolic protection device is considered. Any symptomatic patients undergoing carotid angioplasty and stenting were excluded from the analysis. Patients with dense ischemic cerebral events, such as hemorrhagic conversion and NIHSS >24, were not offered urgent operative management.

CEAs were performed by 1 of 3 board-certified vascular surgeons under general or regional anesthesia, using standard endarterectomy with patch closure. Shunting was used in all cases. Postoperatively, patients were selectively monitored overnight in a postoperative anesthesia care unit and either discharged home or transferred to a standard surgical ward within 24 hours. Patients at risk for cerebral hyperperfusion syndrome, particularly those presenting with acute ischemic events, hypertension, and a high-grade stenosis were monitored in the intensive care unit. Neurologic examinations were performed pre- and postoperatively by a vascular neurologist in patients undergoing urgent CEA; other CEAs were examined by 1 of 3 vascular surgeons. Any patient presenting with a stroke-in-evolution and clinically judged to benefit from revascularization underwent an emergent CEA in <4 hours after presentation.

Adverse outcomes at 30 days were analyzed for each group: TIA, stroke, non-ST or ST-elevated myocardial infarction (NSTEMI or STEMI), and mortality. TIA was defined as a cerebral ischemic event that resolved within 24 hours; stroke was defined as any new cerebral neurologic deficit persisting beyond 24 hours. MI was defined by typical chest pain, elevated serum biomarker troponin I, and determined to be either STEMI or NSTEMI.

The χ^2 test was used to compare the urgent CEA volume before (June 2005–August 2008); after (September 2008–December 2011), a vascular neurology service was implemented. Fisher's exact test was used to analyze perioperative outcomes.

RESULTS

A retrospective review of all CEA for the 39-month period before and after initiation of a stroke/vascular neurology service (between June 2005 thru December 2011) revealed 393 patients that underwent CEA. Demographics and comorbidities were similar between the 2 groups (Table 1). The proportion of urgent CEAs performed increased significantly after initiation of a vascular neurology service (4.1% [7/172] vs. 22.2% [49/221], $P < 0.0001$ via contingency table; Fig. 1A). Per annum, urgent CEAs increased from 5.3% (4/75) in 2005 to 39.6% (25/63) in 2011, $P < 0.0001$ (Fig. 1B). From January 2005 through December 2011, 436 CEAs were performed (Fig. 1B). A dedicated vascular neurology service did not increase the number of symptomatic but did increase the number of electively performed CEAs or asymptomatic CEAs performed. Urgent CEA indications were ocular ischemic events 4% (2/49), cerebral ischemic/infarction events 35% (17/49), crescendo TIAs 6% (3/49), acute stroke 45% (22/49), and stroke-in-evolution 10% (5/49). In patients presenting with acute neurologic symptoms and undergoing CEA during the index hospitalization, thus deemed urgent CEA, mean $ABCD^2$ TIA score was 5 (range 1–8); mean NIHSS was 3.5 (range 0–24). In the urgent CEA group, the mean time to CEA was 3.5 days (range 0–10) after admission. In 5 of 49 cases, patients presented with stroke-in-evolution and the CEA was undertaken emergently in <4 hours.

Although there were no statistical differences in 30-day outcomes, there was a trend toward a higher combined complication rate in the urgent compared with elective symptomatic CEA group (7.1 % [3/49] vs. 2% [1/49]; $P = .36$). This consisted of 1 stroke, 1 death, and 1 MI in the urgent group ($n = 49$) and 1 MI in the symptomatic but electively performed group ($n = 49$). The sole stroke occurred in a patient who presented with crescendo TIAs in the urgent CEA group and both MIs in each group were NSTEMIs. However, patients undergoing urgent CEA with an NIHSS <10 had no perioperative complications. There were no cases of ischemic to hemorrhagic conversion. Lastly, urgent CEAs are associated with an increase in length of stay, compared with symptomatic but electively performed CEAs (mean 2.7 ± 2.1 vs. 7.6 ± 13.1 days, $P < 0.0001$; Fig. 2). This led to higher proportion of urgent CEA patients being discharged to rehabilitation facilities.

DISCUSSION

Our study demonstrates the novel finding that a stroke/vascular neurology service positively affects the volume of urgent CEAs performed over a 3-year period in a tertiary referral center. We cannot find any reports in the literature that describe the practice pattern effects between a stroke/vascular neurology team and vascular surgery on the proportion of urgent CEAs performed. Our data also suggest that periprocedural outcomes for urgent CEAs in patients with stable and unstable neurologic symptoms presenting with NIHSS score <10 is safely tolerated. There is a paucity of data in our vascular surgery literature regarding the NIHSS scores under

Table I. Demographic characteristics of the CEA groups before and after initiation of a stroke/vascular neurology service

Stroke/vascular neurology	Asymptomatic CEA			Symptomatic but electively performed CEA			Urgent CEA		
	Pre	Post	*P* value	Pre	Post	*P* value	Pre	Post	*P* value
n	119	123		46	49		7	49	
Mean age, years (SD)	70.3 (10.0)	70.7 (9.4)	0.46	70 (9.7)	72.4 (8.9)	0.58	61.9 (7.9)	69.8 (10.6)	0.48
Male, n (%)	78 (66)	70 (57)	0.21	23 (50)	30 (61)	0.37	4 (57)	29 (59)	0.91
Indication						0.64			0.11
TIA, *n* (%)	n/a	n/a		34 (74)	33 (67)		6 (86)	22 (45)	
Stroke, *n* (%)	n/a	n/a		12 (26)	16 (33)		1 (14)	27 (55)	

P values for pre—post comparisons within each group calculated using 2-tailed unpaired *t* test for continuous variables (mean age) and χ^2 tests (2-sided) for categorical variables (male sex, indication).

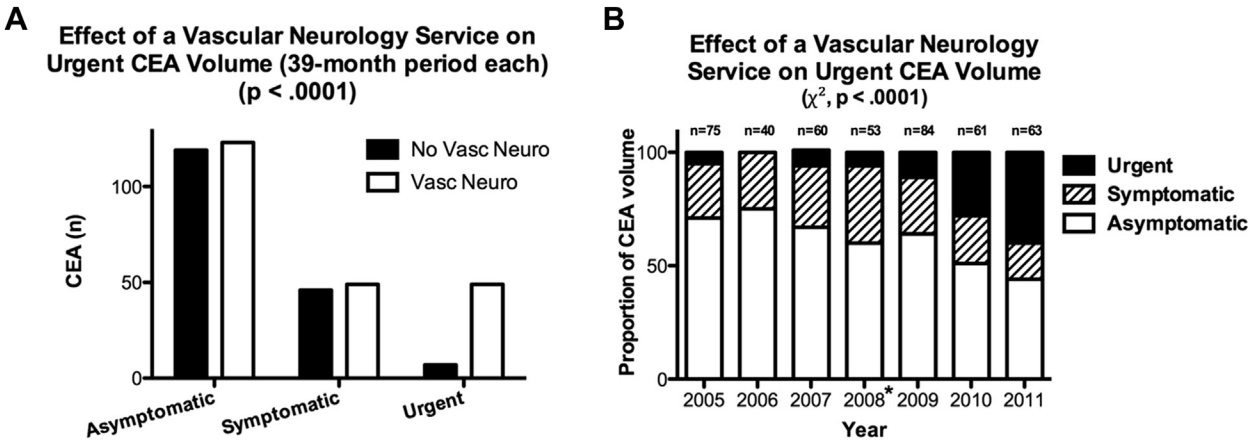

Fig. 1. (A) The proportion of urgent CEAs performed increased significantly after initiation of a stroke/vascular neurology (Vasc Neuro) service. Overall, the incidence of urgent CEAs after implementation of a stroke/vascular neurology program increased from 4.1% (7/172) to 22.2% (49/221) of all CEAs performed ($P < 0.0001$). **(B)** Increase in urgent CEA volume after implementation of a vascular neurology/stroke program. *Program was begun in September 2008. Per annum, urgent CEAs increased from 5.3% (4/75) in 2005 to 39.6% (25/63) in 2011; χ^2, $P < 0.0001$.

which urgent CEAs are well-tolerated, which we describe as NIHSS <10. Another finding is that urgent CEAs are associated with an increased length of stay compared with symptomatic but electively performed CEA. This is likely because of a higher proportion of these patients presenting with poor medical optimization, such as not being on antiplatelet medication, statin therapy, or tight glycemic and blood pressure control. Patients undergoing urgent CEA may require more medical optimization and more postoperative rehabilitation and social services, leading to a longer postoperative hospital length of stay compared with electively performed but symptomatic CEAs. This increased length of stay does lead to increased hospital costs.[12] Strategies to shorten these lengths of stay and cost in this patient population will be important to develop in the future. The increased length of stay noted in the urgent group was primarily due to postoperative care, such as blood pressure control in symptomatic patients who also presented with difficult to control hypertension, and placement into rehabilitation facilities for those who had a persistent neurologic deficit on discharge. Patients admitted without the need for an emergent CEA (e.g., stroke-in-evolution), also spent 1 to 2 days in the hospital before the CEA, during which time more definitive imaging was done and the CEA was placed into the elective operative schedule.

Finally, as evident in Figure 1B, the proportion of asymptomatic patients undergoing CEAs per year has fallen from 69% to 56%. This is an

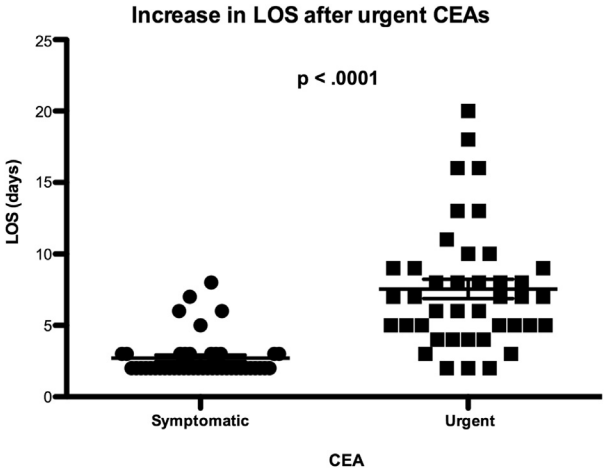

Fig. 2. Urgent CEAs are associated with an increase in length of stay (LOS). Patients undergoing urgent CEA have a marked increased length of stay compared with symptomatic but electively performed CEA (mean 2.7 vs. 7.6 days, $P < 0.0001$).

interesting observation that likely reflects an increasing conservative stance on asymptomatic carotid occlusive disease by our referring physicians and us.

To address whether the increase in urgent CEA volume was coming from a dedicated stroke/vascular neurology service and not from a reduction in CAS volume, we looked at the number of CAS procedures performed per year. Indeed, they remained relatively stable, except for the initial year of 2005. Per year, the number of CAS procedures were (number of procedures in parenthesis following each year): 2005 (5) 2006 (35), 2007 (54), 2008 (53), 2009 (39), 2010 (56), 2011 (46). Hence, an increase in urgent CEAs is indeed coming from a dedicated stroke/vascular neurology service and an increase in the number of CAS performed did not occur during the study period, as did urgent CEAs.

Given the absence of randomized controlled trials supporting the notion of an aggressive approach for a patient with severe carotid-related acute neurologic ischemic symptoms, such as stroke-in-evolution, better protocols need to be developed in the future to determine which patients will benefit from emergent compared with urgent CEA. Increasing evidence supports the notion of an aggressive management for patients presenting with stroke-in-evolution,[6] as we undertook in 5 of 49 patients in our ''urgent CEA'' cohort, leading to revascularization within 4 hours of initiation of symptoms.

In patients who do not present with stroke-in-evolution, there was a recent large Swedish population report that raised 1 caveat.[13] In 2596 symptomatic patients, very urgent CEA, undertaken <48 hours from a TIA or minor stroke, did confer a higher periprocedural risk of stoke and death compared with CEA undertaken on day 3 or later after the qualifying neurologic event (11.5% [17/148] vs. 3.6% [29/804], respectively). Patients treated within 48 hours had a relative odds ratio of 4.24 (confidence interval 2.07–8.70; $P < 0.001$) compared with day 3 and later.[13]

In our study, we did not note a significant difference in 30-day adverse outcomes between the urgent CEA group and the symptomatic but electively performed CEA group ($P = .36$); however, this is likely a type II error given the relatively small sample size. Our data do suggest that for patients with mild-to-moderate strokes (NIHSS <10), an urgent CEA approach is fairly well tolerated. It is hoped that this will span new clinical research strategies that may further define other patient-related factors (such as carotid plaque morphology and presence of particular comorbidities) that may predict a favorable outcome after urgent CEAs.

Our study does have 2 limitations. First, neurologic outcomes were performed by an independent neurologist in all urgent CEAs, whereas elective CEAs did not undergo an independent evaluation. This has the potential to create a reporter bias. Second, CAS cases were excluded from this review. This was done primarily because of the increased periprocedural stroke risk identified in 2 randomized controlled trials with CAS compared with CEA[14,15] and the preference of our stroke/vascular neurology team. Moreover, the International Carotid Stenting Study, which focused solely on treatment of symptomatic carotid disease, found that CAS patients are more five times more likely to develop new post-procedure lesion on MRI compared to CEA.[16] Though the clinical significance of these MRI lesions is unclear, one could postulate possible decreased cognition or increased dementia in future years. Henceforth, patients presenting with acute neurologic ischemic events are primarily routed towards CEA in our institution due to the lower periprocedural stroke risk with CEA compared to CAS. Indeed, in conjunction with our dedicated stroke/vascular neurology service, a clinical pathway was implemented in 2012 at our institution such that all acutely symptomatic carotids are referred by the vascular neurology service to vascular surgery for evaluation and revascularization management. Although CEA has been the preferred primary mode of treatment at our institution by our stroke/vascular neurology team, in select true medically high-risk patients, such as chronic obstructive pulmonary disease with home oxygen dependency or debilitated cardiac disease with ejection fraction

<20%, CAS with proximal protection or embolic protection device has been undertaken in select acute symptomatic patients. Should an intracranial intervention be necessary for neurorescue, a neurointerventional team is available for such endoluminal therapy.

The basis for undertaking an urgent CEA during the index hospitalization is based on natural history data that suggest the risk of stroke after a TIA is near 10% at 7 days.[1] Pooled analysis from CEA trials has demonstrated the greatest benefit within 14 days from the ischemic event and that the benefit falls rapidly with delay of surgery.[4] Certainly there is an absence of level I evidence because there is no randomized trial addressing urgent carotid interventions. A multidisciplinary recommendation from the American Heart/American Stroke Associations deemed a Class IIa, level of evidence B, for undertaking CEA within 2 weeks after a TIA or stroke rather than delaying surgery if there are no contraindications to early revascularization.[17] Because significant stroke reduction may be achieved by undertaking an aggressive approach toward patients presenting with a symptomatic carotid lesion, future research should address new ideas about establishing further novel stroke service lines, rapid access TIA/stroke clinic, and collaborations between vascular surgery and neurology, particularly a stroke/vascular neurology team, in the care of select patients with stable and unstable neurologic symptoms.

CONCLUSIONS

Our study demonstrates that close collaboration between vascular surgery and a dedicated stroke/vascular neurology service positively affects the volume and outcome of urgent CEAs performed in a tertiary referral center. No complications were noted in patients who presented with NIHSS <10.

REFERENCES

1. Giles MF, Rothwell PM. Risk of stroke after TIA: a systemic review and meta-analysis. Lancet Neurol 2007;6:1063–72.
2. Johnston SC, Rothwell PM, Nguyen-Huynh MN, et al. Validation and refinement of scores to predict very early stroke risk after TIA. Lancet 2007;369:283–92.
3. Rantner B, Pavelka M, Posch L, et al. Carotid endarterectomy after ischemic stroke—is there justification for delayed surgery? Eur J Vasc Endovasc Surg 2005;30:36–40.
4. Naylor AR. Occam's razor: intervene early to prevent more strokes! J Vasc Surg 2008;48:1053–9.
5. Rerkasem K, Rothwell PM. Systematic review of the operative risks of carotid endarterectomy for recently symptomatic stenosis in relation to the timing of surgery. Stroke 2009;40:e564–7.
6. Cappoccia L, Sbarigia E, Speziale F, et al. The need for emergency surgical treatment in carotid-related stroke in evolution and crescendo transient ischemic attack. J Vasc Surg 2012;55:1611–7.
7. Annambhotla S, Park MS, Keldahl ML, et al. Early versus delayed carotid endarterectomy in symptomatic patients. J Vasc Surg 2012;56:1296–302.
8. Bazan HA, Pradhan S, Westvik TS, et al. Urgent carotid endarterectomy is safe in patients with few comorbid medical conditions. Ann Vasc Surg 2008;22:505–12.
9. Lavallée PC, Meseguer E, Abboud H, et al. A transient ischaemic attack clinic with round-the-clock access (SOS-TIA): feasibility and effects. Lancet Neurol 2007;6:953–60.
10. Salem MK, Sayers RD, Bown MJ, et al. Rapid access carotid endarterectomy can be performed in the hyperacute period without a significant increase in procedural risks. Eur J Vasc Endovasc Surg 2011;41:222–8.
11. Tsivgoulis G, Stamboulis E, Sharma VK, Heliopoulos I, et al. Multicenter external validation of the ABCD2 score in triaging TIA patients. Neurology 2010;74:1351–7.
12. Sternbergh WC III, Crenshaw GD, Bazan HA, Smith TA. Carotid endarterectomy is more cost-effective than carotid artery stenting. J Vasc Surg 2012;55:1623–8.
13. Strömberg S, Gelin J, Österberg T, et al. Very urgent carotid endarterectomy confers increased procedural risk. Stroke 2012;43:1331–5.
14. Brott TG, Hobson RW 2nd, Howard G, et al. Stenting versus endarterectomy for treatment of carotid artery stenosis. N Engl J Med 2010;363:11–23.
15. International Carotid Stenting Study Investigators-Brown MM, Ederle J, Dobson J, et al. Carotid artery stenting compared with endarterectomy in patients with symptomatic carotid stenosis (International Carotid Stenting Study): an interim analysis of a randomized controlled trial. Lancet 2010;375:985–97.
16. Bonati LH, Jongen LM, Haller S, et al. New ischemic brain lesions on MRI after stenting or endarterectomy for symptomatic carotid stenosis: a substudy of the International Carotid Stenting Study (ICSS). Lancet Neurol 2010;9:353–62.
17. Furie KL, Kasner SE, Adams RJ, et al. Guidelines for the prevention of stroke in patients with stroke or transient ischemic attack: A guideline for healthcare professionals from the American Heart Association/American Stroke Association. Stroke 2011;42:227–76.