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Risk and outcome profile of carotid endarterectomy with proximal intervention is concerning in multi-institutional assessment

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ABSTRACT

Objective: Approaching tandem bifurcation and brachiocephalic disease using carotid endarterectomy (CEA) with ipsilateral proximal endovascular intervention (IPE) has been promulgated as safe and durable. There have been recent concerns about neurologic risk with this technique. The goal of this study was to define stroke and perioperative risk with this uncommon procedure across multiple centers.

Methods: Between August 2002 and July 2016, patients who underwent CEA + IPE were identified by operative records at three institutions. Primary end points were perioperative stroke and death, restenosis, freedom from neurologic event, and need for reintervention. Factors related to these end points were analyzed.

Results: There were 62 patients who underwent CEA + IPE. The average age was 69 ± 9 years. Most were female 34 (55%); 56 (90%) were taking a statin and at least one antiplatelet agent. Bilateral internal carotid stenosis (>50%) was present in 32 (52%); 26 (42%) patients were symptomatic and 12 (19%) had undergone prior ipsilateral CEA. Bifurcation operations included longitudinal CEA/patch (38 [61%]), eversion CEA (20 [32%]), bypass graft (3 [5%]), and CEA/primary repair (1 [2%]). CEA was performed first in 53 (85%). All IPEs included stenting, with a single stent used in 58 (94%). Balloon-expandable stents were placed in the majority of patients (51 [82%]). Proximal arteries treated included the innominate (20 [32%]), left common carotid (32 [52%]), right common carotid (8 [13%]) and both innominate and right common carotid (2 [3%]). IPE was protected by carotid cross-clamp in 48 (77%). Shunting occurred in 14 (23%). There were four (6.5%) perioperative ipsilateral strokes and two hyperperfusion events. There were three (4.8%) operative deaths, one from stroke and two cardiovascular. Combined stroke and death rate was 11.3% and was not different between centers. Mean clinical follow-up was 6 ± 4 years. Mean imaging follow-up was 3 ± 4 years. Restenosis ≥50% at either intervention occurred in 20 (34%). Reintervention was performed for five proximal and three bifurcation failures (14%). Symptomatic status, redo operation, carotid clamp protection, multiple stents, and procedural order were not associated with operative stroke. Carotid clamp protection was associated with less restenosis ($P = .003$). Redo operation ($P = .04$) and hyperlipidemia ($P = .05$) were associated with reintervention. The 5-year actuarial survival was 81%, whereas freedom from stroke and reintervention were 94% and 81%, respectively.

Conclusions: Perioperative stroke and death with CEA + IPE are substantial and consistent across centers. It is strikingly different from isolated CEA or CEA added to open brachiocephalic reconstruction. Restenosis is frequent, and reintervention at either the proximal stent or bifurcation is common. This technical strategy should be used cautiously and selectively reserved for those who are symptomatic with hemodynamically relevant tandem lesions and unfit for open revascularization. (J Vasc Surg 2018;■:1-10.)

Tandem carotid bifurcation and proximal supra-aortic trunk disease is an uncommon form of cerebrovascular disease accounting for 5% or less of treated lesions.[1,2] Effective open surgical and endovascular treatment options exist for both isolated bifurcation stenosis and brachiocephalic disease. However, when these tandem lesions are encountered, optimal treatment approaches and outcomes are less well defined. Several technical methods, including traditional complete open surgical reconstruction and total endovascular angioplasty and stenting from various access approaches, have been discussed.[3-8] Hybrid approaches, including open carotid endarterectomy (CEA) with either antegrade or retrograde supra-aortic trunk angioplasty and stenting, are also described.[9,10]

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The retrograde hybrid approach from an open neck was first depicted by Diethrich et al[11] in 1996. The purported advantages include easier access, arch avoidance, and surgical clamp neuroprotection. It would seem this technical approach could simplify and optimize outcomes with this complex disease pattern. Indeed, in 2011, Sfyroeras et al[9] compiled known series of CEA with ipsilateral proximal endovascular intervention (IPE) in 133 patients into a singular analysis and concluded that the stroke and death risk was similar to that of isolated CEA and it should be recommended for tandem lesions. This was not our perceived experience at Massachusetts General Hospital; thus, we investigated our limited series with this technique and found an operative stroke and death risk significantly higher than our risk with isolated CEA.[12,13] Therefore, colleagues at the Vascular Group in Albany, Dartmouth-Hitchcock Medical Center, and Massachusetts General Hospital joined forces to further investigate the risk and outcomes of CEA + IPE across our centers.

ARTICLE HIGHLIGHTS

- **Type of Research:** Retrospective, multicenter, cohort study
- **Take Home Message:** Tandem carotid bifurcation and brachiocephalic disease was treated in 62 patients with carotid endarterectomy and ipsilateral proximal endovascular intervention, with an 11.3% early stroke and death rate, a 34% restenosis rate (>50%), and a 14% reintervention rate at a mean follow-up of 6 years.
- **Recommendation:** This study suggests that a combined carotid endarterectomy and proximal endovascular intervention strategy to treat tandem lesions should be used selectively and with caution.

METHODS

Patients and data collection. Patients undergoing hybrid CEA + IPE between August 2002 and July 2016 at these three centers were identified. This included carotid bifurcation operation with concomitant retrograde endovascular intervention on the common carotid arteries or the innominate artery (IA). This was accomplished by retrospective review of clinical records and surgeon databases. Institutional research databases were searched cross-referencing *Current Procedural Terminology* codes indicating CEA (35301), redo CEA (35390), or carotid bypass graft (35601) performed in conjunction with any code for open approach for transluminal brachiocephalic angioplasty (35458), transluminal stent placement (37207), or stent intrathoracic carotid artery or IA (37218).

Operative reports and records were reviewed to confirm operative conduct. Patients were excluded if they underwent open access for retrograde endovascular intervention only without associated bifurcation surgery. Included patients constituted the CEA + IPE cohort. Patients' demographics and clinical data as well as operative conduct and perioperative and intraoperative factors were collected through retrospective review of hospital medical records. Preoperative lesion detail was collected by review of carotid duplex ultrasound and relevant anatomic imaging studies. Long-term stroke, restenosis, and reintervention were gathered by reviewing outpatient medical records. The preoperative assessment and postoperative follow-up of all patients were institution specific and at the discretion of the operating surgeon based on index reconstruction status and other cerebrovascular lesions or disease. Long-term survival was determined using the outpatient medical record and the Social Security Death Index. Patients' data from each institution were deidentified and then collated into a singular cohort of patients. The Institutional Review Boards at the three participating institutions approved this clinical investigation and did not require consent of the patient.

Definitions and end points. Patients were considered symptomatic if diagnosis of ipsilateral stroke, hemispheric transient ischemic attack, or amaurosis fugax occurred within 6 months of operation. Restenosis was defined as 50% or greater index internal carotid artery duplex ultrasound criteria in each institution's accredited vascular noninvasive laboratory indicating CEA site restenosis, recurrence of common carotid artery duplex ultrasound findings suggesting proximal restenosis, or 50% or greater stenosis on anatomic imaging at either the CEA or IPE site (Table I). Reintervention was defined as any recurrent open surgical or endovascular procedure required to treat the carotid bifurcation or proximal vessel addressed at the index CEA + IPE. Primary end points included 30-day and long-term stroke, restenosis, reintervention, and death.

Statistical analysis. All statistical calculations were accomplished using SAS 9.2 software (SAS Institute, Cary, NC). Continuous variables are expressed as mean ± standard deviation. Dichotomous variables are described as percentage of the cohort. Univariate associations with end points were performed with two-tailed Student *t*-test or Wilcoxon rank sum testing for continuous variables and Pearson χ^2 testing for dichotomous variables. A P value of $<.05$ was considered significant. Survival, freedom from stroke, and freedom from reintervention or restenosis were calculated using Kaplan-Meier actuarial methods. Actuarial estimates are reported curtailed to the point at which standard error becomes 10% or greater owing to the cohort size.