Variability in Carotid Endarterectomy at a Single Medical Center: An Outcome and Cost Analysis

Sibu P. Saha, MD, MBA¹ Peter M. Rodgers-Fischl, MS^{1,2} David J. Minion, MD¹
Victor A. Ferraris, MD, PhD¹ Daniel L. Davenport, PhD¹

¹ Department of Surgery, University of Kentucky, Lexington, Kentucky

² University of Kentucky College of Medicine, Lexington, Kentucky

Address for correspondence and reprint requests Sibu P. Saha, MD, MBA, Department of Surgery, University of Kentucky, A301, Kentucky Clinic, 740 South Limestone, Lexington, KY 40536-0284 (e-mail: ssaha2@uky.edu).

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Abstract

Carotid endarterectomy (CEA) is a common surgical procedure. Its efficacy in the prevention of stroke has been proven by multiple clinical trials including North American Symptomatic Carotid Endarterectomy Trial and Asymptomatic Carotid Atherosclerosis Study. Currently, there is a wide variability in the technique of this operation. This study was performed to determine the variability of CEA at the University of Kentucky Medical Center with a focus on cost and short-term outcome. We reviewed the charts of a consecutive series of 349 patients undergoing CEA at our institution. We analyzed the variability in shunt used across surgeons, intraoperative variables, cost, and outcome. Data on 374 procedures on 349 patients who underwent CEA showed shunt utilization varied significantly by surgeon from 3 to 94%. Patch utilization also varied significantly by surgeon. Two in-hospital deaths occurred in the shunt group (1.3%) and none in the no-shunt group. Shunt placement was associated with 1 hour 24 minutes increase in operative time from 2 hours 3 minutes in the no-shunt group to 3 hours 27 minutes in the shunt group (*t* test, *p* < 0.01). Shunt placement was associated with a 1.74-day increase in length of stay, from 2.97 days in the no-shunt group to 4.71 days in the shunt group. There was no significant difference in the cost of procedure in these two groups: no-shunt \$11,510 ± \$3,977, shunt group \$11,479 ± \$4,030. This study showed no significant difference in cost or outcome between various techniques.

Keywords

- carotid endarterectomy
- stroke
- stenosis
- shunt
- patch
- cost analysis
- outcomes
- mortality
- morbidity

Stroke is the leading cause of long-term disability in the United States and the fourth leading cause of mortality.¹ Over 87% of those strokes are of ischemic origin, and ~20% of this subset is due to large artery stenosis.² A reduction in stroke rate in patients with carotid artery stenosis could therefore result in an overall reduction in mortality and morbidity due to stroke and substantially affect cost and savings.

Carotid endarterectomy (CEA) is a common surgical procedure proven in large clinical trials to cost effectively reduce stroke risk and recurrence in patients with symptomatic and/or asymptomatic large artery stenosis.^{3–5} CEA and arterial reconstruction can be performed in a variety of ways including standard endarterectomy with primary closure, standard endarterectomy with patch closure, shunt-placed endarterectomy with primary closure, and shunt-placed endarterec-

tomy with patch closure. Currently, there is wide variability in technique of this operation and limited statistical evidence regarding the risks and benefits of one particular method versus another.^{6–9} With procedural variability potentially leading to an increase in the amount of dollars spent per procedure,¹⁰ we decided to investigate the procedural variability of CEA at the University of Kentucky Medical Center with a focus on hospital outcomes, 30-day morbidity and mortality, and cost.

Methods

We reviewed the charts of a consecutive series of 349 patients undergoing CEA at our institution. We analyzed the variability in shunt used across surgeons, intraoperative variables, cost, and outcome.

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Table 1 Symptoms and comorbid risks

Variable	Without shunt	With shunt	p value ^a
No. of procedures	214	160	
Prior CEA (%)	15.4	14.4	0.88
Symptomatic (TIA, stroke or amaurosis fugax) (%)	59.3	75.0	< 0.01
Age, mean years $\pm$ SD	65.9 $\pm$ 9.9	64.6 $\pm$ 10.1	0.20
Male (%)	56.1	58.8	0.67
Hx atrial fibrillation (%)	5.6	12.5	0.02
Hx coronary artery disease (%)	37.9	33.8	0.48
Hx peripheral vascular disease (%)	39.7	33.1	0.20
Hx hyperlipidemia (%)	63.6	70.6	0.18
Hx hypertension (%)	83.6	85.6	0.67
Hx myocardial infarction (%)	19.6	20.6	0.90
Hx diabetes	40.2	29.4	0.04
Ever smoked (%)	46.7	48.8	0.75

Abbreviations: CEA, carotid endarterectomy; Hx, history; SD, standard deviation; TIA, transient ischemic attack.

^ap values are from Fisher exact test for binary variables and *t* test for age.

Results

Data from 374 CEA procedures on 349 patients were reviewed. Symptoms and comorbid risks in the procedures with and without shunt are shown in **Table 1**. Shunt utilization varied significantly by surgeon (chi-square, $p < 0.01$) with 43% in the group as a whole and ranged by surgeon from 3 to 94%. Patch utilization also varied significantly by surgeon (chi-square, $p < 0.01$), correlated ($r = 0.78$, $p < 0.01$), with 40% patch utilization in the group as a whole. Two in-hospital deaths occurred in the shunt group (1.3%), none in the no-shunt group. There were three stroke/transient ischemic attack/hemiplegia occurrences in the shunt group (1.9%) and two in the no-shunt group (0.09%). There were four instances of altered mental status in the shunt group (2.5%), three in the no-shunt group (1.4%). One a-fib occurred in the shunt group (0.6%), two in the no-shunt group (1.4%). Eight of 160 in the shunt group (5.0%) returned to the OR, while 5 out of 214 (2.3%) of the no-shunt group did (chi-square, $p = 0.25$). Shunt placement was associated with 1 hour 24 minutes increase in operative time from 2 hours 3 minutes in the no-shunt group to 3 hours 27 minutes in the shunt group (*t* test, $p < 0.01$). Shunt placement was associated with a 1.74-day increase in length of stay, from 2.97 days in the no-shunt group to 4.71 days in the shunt group. There was no significant difference in the cost of these two groups: no-shunt $\$11,510 \pm \$3,977$, shunt group $\$11,479 \pm \$4,030$ (**Table 2**).

Discussion

Although CEA has proven superior in large clinical trials in the reduction of stroke risk and recurrence, the optimal method or technique remains elusive.³⁻⁵ Traditionally, the surgeon performing the procedure has been free to select his or her

preference for a particular technique. Systematic analysis has shown excellent results for the procedure with a great variety of methods including primary closure with or without shunt-placed endarterectomy and patch endarterectomy with or without shunt placement.³⁻⁵ The overall results that specifically compare one technique to another, however, remain less clear.⁶⁻⁹

The argument for the practicality of shunt placement stems from the potential reduction of perioperative stroke risk through the minimization of the loss of cerebral blood flow during clamping. Advocates of routine shunting suggest that the technique increases surgeon experience and reduces time spent with patient neurological monitoring. Opponents of routine practice, however, argue that shunting is only necessary in a small percentage of cases.^{10,11} Additionally, they also argue that the benefits of shunting can be outweighed by complications that include the risk of air and/or plaque emboli formation during the carotid dissection.^{10,12} In either case, the shunting procedure comes not without potential for additional cost and with little to no systemic analytical support.^{7,8,11}

Proponents for patch closure endarterectomy argue that the procedure helps to prevent the occurrence of early thrombosis and late re-stenosis of the carotid artery. However, such data may fail to show usefulness in stroke.^{6,7} Additionally, routine patching is associated with increased carotid occlusion time, a greater number of sutures, and an increased risk of rupture.^{6,7} Once again, addition of a variable to standard closure CEA comes not without potential for additional cost, and little analytical support is available.^{6,7,10}

In general, the selection of procedure for CEA may frequently require the surgeon to make case-by-case decisions based on age, gender, and condition of the individual patient due to the fact that individual techniques are not

Table 2 Perioperative variables and outcomes

Variable	Without shunt	With shunt	<i>p</i> value ^a
Number of procedures	214	160	
Patch utilized (%)	22.9	61.9	< 0.01
Operative duration, mean min. $\pm$ SD	124 $\pm$ 77	208 $\pm$ 64	< 0.01
Transfused intraoperatively (%)	1.9	0.6	0.33
Transfused within 72 hours, postop. (%)	1.9	5.6	0.08
ICU stay (%)	46.7	30.6	< 0.01
Length of hospital stay, median days (interquartile range)	2 (2–3)	2 (1–5)	0.20
Returned to operating room (%)	5 (2.3%)	8 (5.0%)	0.25
In-hospital death (%)	0 (0.0%)	2 (1.3%)	0.18
Postop. stroke, TIA, or hemiplegia (%)	2 (0.9%)	3 (1.9%)	0.66
Altered mental status (%)	3 (1.4%)	4 (2.5%)	0.47
Atrial fibrillation (%)	2 (0.9%)	1 (0.6%)	1.00
Discharged to rehab. hospital (%)	1.9	4.4	0.22
Mean total costs for 2008 cases, <i>n</i> = 31 and 17, respectively, with 2 shunt outliers removed	11,510 $\pm$ 3,977	11,479 $\pm$ 4,030	0.98

Abbreviations: ICU, intensive care unit; SD, standard deviation; TIA, transient ischemic attack.

^a*p* values are from Fisher exact test for binary variables, median test for length of stay, and *t* tests for operative duration and costs.

suitable for all patients and that a carotid shunt is not always easily inserted. Additionally, the experience of the surgeon with one individual technique over the other may play a significant role in the surgeon's individual procedural preference. A surgeon with a preference for the patch technique is not likely to alter his surgical approach without evidence to support doing so.

An explanation for our findings can be attributed not only to the surgeon's own individual preference but also to sample size. Our samples are too small to account for type II errors. The systematic review of cases at our institution may not necessarily reflect those seen from a larger national sample but in general reflect what has been shown thus far in the literature.

Conclusion

The technique of CEA varies among surgeons in a single institution with no significant difference in cost or outcome.

Summary

In summary, a review of both the patch and shunt techniques performed by highly qualified surgeons at the University of Kentucky Medical Center has shown that there was no statistical differences in death, stroke, length of stay, or costs in the two groups. The findings reflect surgeon preference, experience, and lack of available evidence-based recommendations for the technical performance of CEA.

References

- 1 Roger VL, Go AS, Lloyd-Jones DM, et al; American Heart Association Statistics Committee and Stroke Statistics Subcommittee. Heart disease and stroke statistics—2012 update: a report from the American Heart Association. *Circulation* 2012;125(1):e2–e220
- 2 Barnett HJ, Gunton RW, Eliasziw M, et al. Causes and severity of ischemic stroke in patients with internal carotid artery stenosis. *JAMA* 2000;283(11):1429–1436
- 3 Barnett HJ, Taylor DW, Eliasziw M, et al. Benefit of carotid endarterectomy in patients with symptomatic moderate or severe stenosis. North American Symptomatic Carotid Endarterectomy Trial Collaborators. *N Engl J Med* 1998;339(20):1415–1425
- 4 Ferguson GG, Eliasziw M, Barr HW, et al. The North American Symptomatic Carotid Endarterectomy Trial: surgical results in 1415 patients. *Stroke* 1999;30(9):1751–1758
- 5 Endarterectomy for asymptomatic carotid artery stenosis. Executive Committee for the Asymptomatic Carotid Atherosclerosis Study. *JAMA* 1995;273(18):1421–1428
- 6 Rerkasem K, Rothwell PM. Patch angioplasty versus primary closure for carotid endarterectomy. *Cochrane Database Syst Rev* 2009;4(4):CD000160
- 7 Byrne J, Feustel P, Darling RC III. Primary closure, routine patching, and eversion endarterectomy: what is the current state of the literature supporting use of these techniques? *Semin Vasc Surg* 2007;20(4):226–235
- 8 Aburahma AF, Mousa AY, Stone PA. Shunting during carotid endarterectomy. *J Vasc Surg* 2011;54(5):1502–1510
- 9 Wennberg JE, Fisher ES, Stukel TA, Sharp SM. Use of Medicare claims data to monitor provider-specific performance among patients with severe chronic illness. *Health Aff* 2004; Suppl Variation:VAR5–18

- 10 Kret MR, Young B, Moneta GL, et al. Results of routine shunting and patch closure during carotid endarterectomy. *Am J Surg* 2012; 203(5):613–617
- 11 Aburahma AF, Stone PA, Hass SM, et al. Prospective randomized trial of routine versus selective shunting in carotid endarterectomy based on stump pressure. *J Vasc Surg* 2010;51(5): 1133–1138
- 12 Frawley JE, Hicks RG, Gray LJ, Niesche JW. Carotid endarterectomy without a shunt for symptomatic lesions associated with contralateral severe stenosis or occlusion. *J Vasc Surg* 1996;23(3):421–427