

The changing face of carotid endarterectomy

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Purpose: The economic milieu and improvements in care have altered the diagnostic and therapeutic algorithm of the patient with carotid stenosis. This study analyzes the efficacy and safety of these changes.

Methods: The records of patients who underwent 320 consecutive carotid endarterectomies performed by three surgeons at our institution from 1990 to 1994 were reviewed retrospectively. Use of diagnostic angiography, use of carotid duplex ultrasound, length of hospital stay, postanesthesia recovery observation, intensive care unit (ICU) observation, complications, and hospital charges were analyzed.

Results: The average length of hospital stay decreased from 6.18 days to 2.00 days ($p \leq 0.001$). The day of discharge decreased from 3.10 days to 1.24 days after surgery ($p \leq 0.01$). By 1993, 68% were discharged by the first day after surgery, increasing to 73% by 1994. From 1990 to 1992, average postoperative ICU observation time fluctuated between 18 and 25 hours; this time decreased to 12.2 hours by 1994. In 1993, only 12.5% of patients were admitted to the ICU, down from 94.8% in 1990; by 1994, only 7.3% were admitted to the ICU ($p \leq 0.001$). Postanesthesia recovery observation time decreased from 3.77 hours to 1.63 hours during this time ($p \leq 0.04$). With regard to preoperative diagnosis, angiography was performed in 93.1% of patients in 1990; by 1994, only 32.8% underwent this procedure ($p \leq 0.0001$). Average hospital charges decreased significantly (1990, \$14,378; 1994, \$10,436) with these modifications in patient care ($p \leq 0.001$). The complication rate reflected no significant changes over the course of the study. There were six incidences of cerebrovascular accident (6/320, 1.9%), including one death. There were four incidences of transient ischemic attack (4/320, 1.3%), with no significant differences noted from year to year.

Conclusions: This study confirms the changing nature of carotid endarterectomy and documents that these changes have not adversely affected the safety of the operation. (*J VASC SURG* 1996;23:622-7.)

Approximately 100,000 carotid endarterectomies are performed in the United States each year.¹ During the past decade, advances have been made in the diagnosis and management of atherosclerotic disease involving the carotid bifurcation. These advances and the changing economic milieu of cost containment have pressured surgeons to reduce health care expenditures without compromising the quality of patient

outcome or care. The advanced age and associated medical comorbidities of vascular patients further complicates this issue.^{2,3}

Modifications of conventional diagnostic and therapeutic algorithms have been suggested.⁴⁻⁶ We examine the efficacy of implementing changes related to preoperative assessment, postoperative observation, hospital charges, and most importantly, patient safety.

METHODS

We retrospectively reviewed the medical records of patients who underwent 320 consecutive carotid endarterectomies performed by three surgeons at Loyola University Medical Center from January 1, 1990, to December 31, 1994. Only patients who underwent carotid endarterectomy as the primary procedure were included in the study. Combined procedures, such as coronary artery bypass/carotid

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Presented at the Annual Joint Meeting of the Society of Vascular Surgery and the International Society for Cardiovascular Surgery, North American Chapter, New Orleans, La., June 11-14, 1995.

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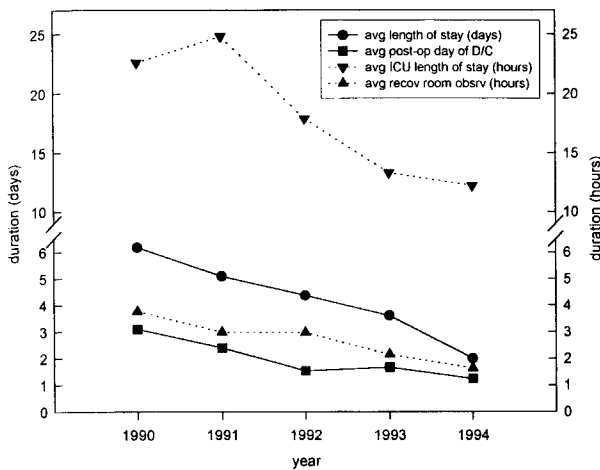


Fig. 1. Hospital resource use in patients undergoing carotid endarterectomy (1990 to 1994). Note large decreases in average length of stay and ICU observation.

endarterectomy and subclavian-carotid artery bypass, were excluded from this analysis.

Information regarding demographics, preoperative assessment, operative course, and postoperative management was obtained from hospital medical records, operative logs, and an institutional database. Financial data were obtained from the hospital financial operations office. Statistical analysis was performed with Student's *t* test for continuous variables and the Mann-Whitney rank sum test in groups whose means conform to nonnormal distributions. Significance was assigned for *p* values ≤ 0.05 .

RESULTS

Three hundred twenty carotid endarterectomies were performed in 284 patients during the period of review. General anesthesia was used for all patients. These patients served as the basis for the demographic and outcome data (Table I).

Patient ages ranged from 39 to 87 years, with a mean of 67.28 years. Two hundred four (72%) were undergoing medical treatment for hypertension, 94 (33.0%) had a documented history of myocardial infarction, and 84 (29.6%) had a history of coronary artery bypass grafting (CABG). Preoperative cardiac assessment included nucleotide cardiac perfusion scanning (thallium imaging) in 68.5% of patients (157 of 229) from 1990 to 1993, decreasing to 45.7% (32 of 70) in 1994. This decrease reflected a refinement in evaluating the indications for thallium scanning. Cardiac catheterization was performed in 24.3% of patients found to have reversible defects (69 of 284). Twenty-one of these 69 patients (30.4%) had previ-

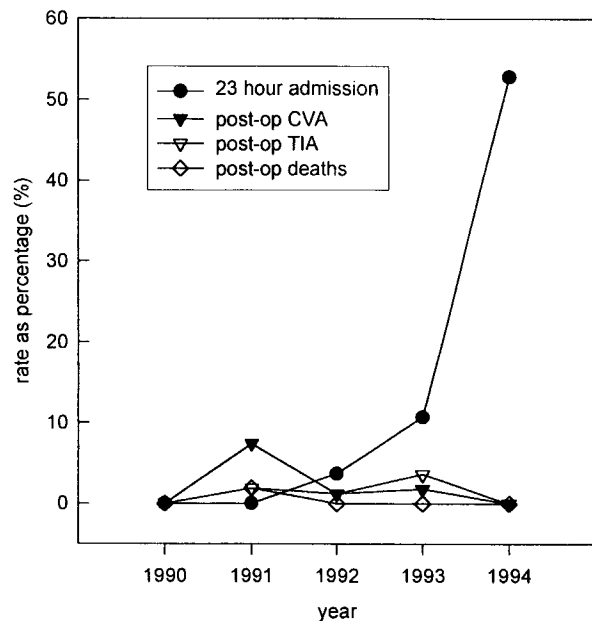


Fig. 2. Comparison of same-day admission rates and complication rates after carotid endarterectomy (1990 to 1994).

ously undergone CABG or percutaneous transluminal coronary angioplasty.

Eighteen patients underwent staged bilateral carotid endarterectomies. Two hundred thirty-six procedures (73.8%) were performed for symptomatic disease. One hundred forty-one patients (44.1%) had transient ischemic attacks (TIAs), 76 (23.8%) had reversible ischemic neurologic deficits or documented cerebrovascular accidents (CVAs), and 9 (2.8%) experienced amaurosis fugax. The percentage of patients who underwent surgery for asymptomatic disease increased from 14% in 1990 to 35% in 1994 ($p \leq 0.05$; Table I).

Angiography. Preoperative assessment of carotid artery disease radically shifted from carotid angiography to noninvasive duplex ultrasound scanning during this 5-year study period. In 1990, 93.1% of patients (54 of 58) underwent contrast cerebral angiography before surgery. By 1994, only 32.8% (23 of 70) underwent this procedure ($p \leq 0.0001$) either electively as an outpatient procedure or as an urgent inpatient diagnostic tool. Concomitantly, carotid duplex scanning increased to include 100% of patients before surgery by 1994 and was the only method of carotid assessment in 60.7% (34 of 56) and 67.1% (47 of 70) of patients in 1993 and 1994, respectively.

Intensive care unit (ICU). From 1990 to 1992, all patients were admitted to the ICU for postoperative observation. Average ICU observation time

Table I. Patient demographics

Demographic feature	1990	1991	1992	1993	1994
Total no. of patients	58	54	82	56	70
Age (yr)	69	63	68	67	67
Male (%)	61	56	57	54	60
Female (%)	39	44	43	46	40
History of hypertension (%)	76	70	67	72	73
History of myocardial infarction (%)	35	34	30	28	34
History of CABG (%)	24	43	21	24	26
Preoperative thallium scan (%)	62	64	77	72	46
Preoperative cardiac catheterization (%)	35	22	16	20	18
Preoperative TIA/CVA (%)	86	81	74	73	65
Asymptomatic before surgery (%)	14	19	26	27	35

ranged from 17.9 to 24.8 hours during these 3 years (Fig. 1). By late 1992, however, modifications in discharge criteria, including direct discharge from the ICU versus 12 hour observation in the surgical ward after ICU transfer, led to 22% of patients (18 of 82) being discharged from the ICU. In 1993 only 12.5% (7 of 56) were admitted to the ICU ($p \leq 0.001$), and by 1994 7.3% (65 of 70) were admitted to the ICU ($p \leq 0.001$; Fig. 2). Of patients admitted to the ICU from 1993 to 1994, average observation times also decreased from 13.3 hours in 1993 to 12.2 hours in 1994. Postanesthesia recovery room observation time remained relatively constant at an average of 3.24 hours from 1990 to 1992; however, postanesthesia recovery time decreased to 2.10 hours in 1993 and 1.63 hours in 1994 ($p \leq 0.04$; Fig. 1).

Discharge data. The mean postoperative day of discharge decreased dramatically from 1990 to 1994. In 1990, patients were discharged 3.10 days after surgery; by 1994, patient discharge occurred 1.24 days ($p \leq 0.01$) after surgery (Fig. 1). Overall, these changes were reflected in a large decrease in average length of stay. From 1990 to 1994, the average hospital stay decreased from 6.18 days in 1990 to 2.00 days in 1994 ($p \leq 0.001$). By separating the data further, 67.9% of patients were discharged by the first day after surgery in 1993, increasing to 72.9% in 1994. In 1990 and 1991, no patients were admitted under 23-hour/same-day surgery observation criteria. By 1994, 53% of patients were scheduled and discharged as 23-hour admissions (Fig. 2).

Clinical results. Of 320 carotid endarterectomies performed, six incidences (1.9%) of postoperative CVA occurred (including one death), and four documented TIAs occurred (1.3%), giving a complication rate of 3.1% (10 of 320). Year-to-year analysis showed no significant trends or significant differences (Figs. 2 and 3). Other postoperative complications included nine neck hematomas (two patients required a return

to the operating room for reexploration), four myocardial infarctions (one patient required CABG), six cardiac arrhythmias (all patients were treated medically), and two traction nerve injuries that spontaneously resolved over time. Of the 10 patients with cardiac complications after surgery, only one was found to have a positive result on preoperative cardiac testing (reversible defect on thallium scanning). None of the patients admitted to the surgical floor had postoperative complications that necessitated transfer to the ICU. Thirty-day follow-up of all patients revealed no evidence of missed complications.

Savings. Hospital charges during the study initially rose from $\$14,378 \pm \7587 in 1990 to $\$15,341 \pm \7365 in 1991, then decreased dramatically (32%) to $\$10,437 \pm \3117 by 1994 ($p \leq 0.001$; Fig. 4). This trend followed that associated with decreasing length of stay (Fig. 1). Examination of itemized hospital charges revealed that daily basic ICU rates increased by 29% (1990, $\$1,115$; 1994, $\$1,570$), compared with an 18% increase in the standard surgical floor room rate (1990, $\$460$; 1994, $\$560$). The financial impact of four-vessel cerebral angiography was also noted. In 1990, the charge for this procedure averaged $\$1,196$ and increased to $\$1,397$ in 1994, excluding professional fees. Only 32.8% of patients, however, underwent this procedure in 1994. The average hospital charge for duplex carotid ultrasound scanning also increased by approximately 14% (1990, $\$345$; 1994, $\$399$), the same rate as carotid angiography (Fig. 4).

DISCUSSION

Concerns about the increasing cost of health care, coupled with the rapidly expanding technology of the past 10 years, have placed physicians at the crux of a controversial issue—providing quality care while maximizing hospital resources at minimal cost. The evolution of the diagnosis and treatment of patients

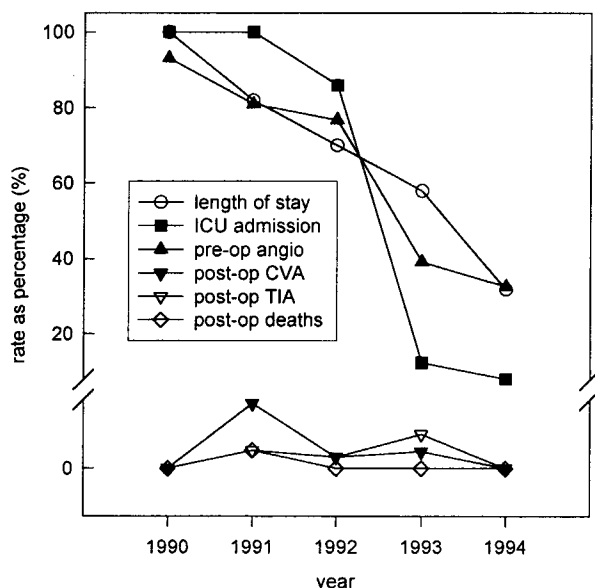


Fig. 3. Comparison of complication rates after carotid endarterectomy and hospital resource use. Note steady low postoperative CVA, TIA, and death rates as length of stay, ICU admission, and use of preoperative angiography steadily decrease.

with carotid artery stenosis is one example of this conundrum. Although the current economic milieu emphasizes cost containment and limited third-party reimbursement, ongoing studies such as the NASCET,⁷ the Veterans Administration Cooperative Study,⁸ and the ACAS⁹ identify an increasing number of patients who may benefit from carotid endarterectomy. With these conflicting issues at hand, we undertook this investigation.

Many recent studies support performing carotid endarterectomy without routine preoperative cerebral angiography.^{10,11} A number of groups have reported experience with duplex ultrasound as the only preoperative imaging analysis before surgery,¹²⁻¹⁴ establishing concordance between duplex scanning and angiography before initiating prospective investigations. Our data reflect an evolving confidence in the vascular laboratory with increasing dependence on the duplex scan over the 5-year study. The sine qua non of this policy is an accredited vascular laboratory of proven excellence.¹⁵ We also agree with others that arteriography should be selectively used when patients have unusual symptoms, when duplex results are equivocal, or when the ultrasound scan is technically inadequate.¹⁶ We currently do not routinely use other adjunctive tests such as computed tomography or magnetic resonance imaging. By avoiding routine

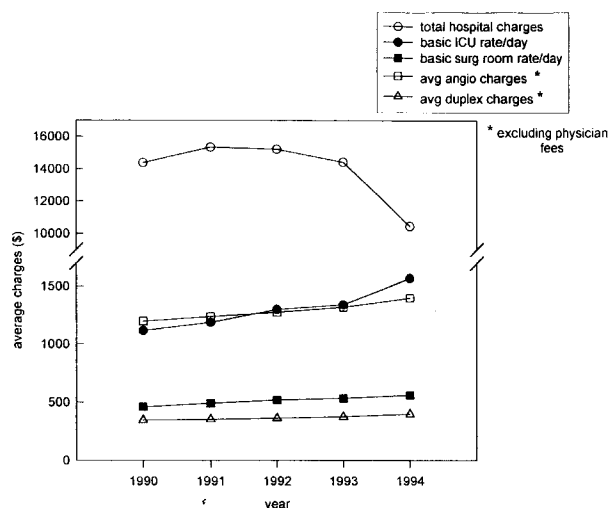


Fig. 4. Review of hospital charges in patients undergoing carotid endarterectomy (1990 to 1994).

angiography our study realized an average savings of 20% to 25%, which increased to almost 40% if professional fees were included.

Traditionally, all of our carotid endarterectomy patients have been observed in an ICU setting for 24 hours after surgery. O'Brien and Ricotta¹⁷ found that only 18% of their patients required ICU admission. In fact, criteria for ICU admission developed in only 3 of 73 patients (4.1%) more than 3 hours after surgery. A recent review of 100 patients from 1991 and 1992 demonstrated that only one preoperative factor reliably predicted potential ICU observation—significant hypertension.¹⁸ When patients were taken as a group, we also found a relationship in those with histories significant for hypertension, coronary artery disease, recent CVA, or all of these; these patients appeared more likely to require ICU admission. Using these criteria plus a short monitoring period (1.5 to 3 hours) in the recovery room, 99% of observed patients could have been transferred to the surgical floor without ICU management. Our study showed that using this revised protocol decreased postoperative ICU admissions from 94.8% in 1990 to 7.2% in 1994 with no increase in morbidity or mortality rates. Of the 19 patients recognized in the recovery room with complications that necessitated either a return to the operating room or ICU admission, none met our current indications for ICU observation before surgery. Carotid endarterectomy patients have a high incidence of hypertension and coronary artery disease (Table I); yet in our entire study only four patients had a myocardial infarction

(one required CABG), and six patients were treated medically for cardiac arrhythmias. These results occurred despite the above-cited reduction in ICU observation and a decreasing reliance on thallium scanning. This area of patient care will require constant vigilance as indications for preoperative testing and postoperative monitoring evolve.

In 1992 Collier¹⁹ reported that only 10% of his patients who underwent carotid endarterectomy needed ICU admission, 88% were discharged by the first day after surgery, none died within 30 days, and none were readmitted for hypertension, hemorrhage, or cardiac or neurologic events. Collier suggested that the use of local anesthesia contributed to his good results and shortened hospital stay. In our series, only 7.2% of patients required ICU admission by 1994, and 72.9% were discharged on the first day after surgery; no deaths or readmissions were noted, yet all of our patients had general anesthesia. Although this study is based on retrospective analysis, the data support the contention that same-day admission and early discharge can be accomplished in high-risk patients undergoing general anesthesia and carotid endarterectomy at a university-based institution. It must be stressed that these results and our conclusions may not be applicable to all patient populations or hospital practices. Various differences in population dynamics, socioeconomic climate, and health care organization policies can influence the ability to implement changing practice patterns.

The changes reported in this study, such as decreases in length of hospital stay, use of the ICU, preoperative angiography, and postanesthesia recovery/ICU observation times resulted in a decrease in overall hospital charges of 32% from a peak average of \$15,340 in 1991 to \$10,436 in 1994. Attempts at applying various formulae and models to better understand these results have been unsuccessful. The relationship between charges and costs is difficult to identify with accuracy. During this study period (1990 to 1994) the inflation rate remained steady, between 3.0% and 5.5%. Health care inflation increased more rapidly during this period, however, despite changes in Medicare reimbursement, managed care input, and hospital reorganization. Therefore the 32% decrease in hospital charges occurred during a time of rapid inflation in health care expenditures.

CONCLUSION

The role of both physician and surgeon is to deliver patient care of the highest quality. Economic factors may modify our care but must not modify our

quality of care. Our mortality rate of 0.3%, stroke rate of 1.9%, and postoperative TIA + CVA rate of 3.1% compare favorably with previously described standards established over the previous 2 decades.²⁰⁻²² In addition to achieving these low complication rates, we were able to decrease mean length of stay by 68% (6.18 days decreasing to 2.00 days).

Our results suggest that cost savings can be accomplished without jeopardizing patient outcome. Cost containment was achieved by using same-day hospital admission; avoiding routine preoperative angiography; and increasing use of duplex ultrasound scanning, selective ICU admission, and early hospital discharge. Ongoing studies investigating preoperative clinical laboratory use, anesthesia department use during surgery, and further refinement of the current protocol for postoperative patient care may continue to decrease costs. This study confirms the changing nature of carotid endarterectomy and documents that these changes have not adversely affected the safety of the operation. Future studies should emphasize these same principles.

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Submitted July 13, 1995; accepted December 21, 1995.