Using Physician Claims to Identify Postoperative Complications of Carotid Endarterectomy

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Objective. This study develops a methodology for identifying complications following carotid endarterectomy, using physician claims data.

Data Sources/Study Setting. We selected a random 20 percent sample of Medicare patients undergoing carotid endarterectomy in 1991 ($n = 8,345$) and extracted all of their claims.

Study Design. Project neurologists identified the following services as indicative of complications following carotid endarterectomy if they were provided within 30 days of surgery: head CT, head MRI, and surgical exploration of the neck for hemorrhage, thrombosis, or infection.

Data Collection/Extraction Methods. Total costs were calculated from all claims associated with the hospitalization and the 30-day postoperative period. Outcomes included mortality (obtained from Medicare eligibility files), length of stay, discharge to an institution, and readmission to an acute care hospital (the latter obtained from claims data).

Principal Findings. Surgical complications were identified in one out of every ten endarterectomy patients (10.3 percent). Patients with complications were significantly more likely to die within 30 days of surgery (8.9 percent, compared with 1.1 percent of those not experiencing complications). They also were significantly more likely to be discharged to an institutional setting (24.9 percent versus 2.9 percent), and more likely to be readmitted to acute care hospitals (26.8 percent versus 8.2 percent). Patients with postoperative complications also were significantly more expensive: $22,187 versus $10,892.

Conclusion. Our findings suggest that physician claims could be used by PROs or similar entities as a screening tool to identify potential problem hospitals or problem surgeons. First, however, the methodology would need to be clinically validated.

Key Words. Postoperative complications, quality of care, carotid endarterectomy

While mortality rates are commonly used to evaluate surgical outcomes, such measures fail to identify nonfatal, but costly, complications, especially among procedures with generally low death rates. Low postoperative mortality rates for a group of providers may appear acceptable but obscure the fact that individual surgeons or individual hospitals are experiencing excessively high rates of avoidable complications. Carotid endarterectomy, a procedure used to prevent cerebral infarction (stroke) in at-risk patients, is a good example of such an operation. This procedure is most commonly performed on the elderly; about three-quarters of all endarterectomies in 1990 were provided to Medicare patients (Graves 1992). Although 30-day mortality for the elderly is quite low, about 2 percent, several studies have shown that nonfatal strokes and myocardial infarctions following surgery increase the overall complication rate substantially (Brook, Park, Chassin, et al. 1990; Fisher, Malenka, Solomon, et al. 1989; McCrory, Goldstein, Samsa, et al. 1993). Total complication rates (death plus nonfatal stroke or MI) ranged from 6.9 percent of patients of all ages in 12 academic medical centers (McCrory, Goldstein, Samsa, et al. 1993) to 11.3 percent in patients aged 65 and older in three geographic areas of the United States (Brook, Park, Chassin, et al. 1990).

These prior studies have identified patient characteristics associated with postoperative complications of carotid endarterectomy but, with the exception of patient age, these factors can be determined only by medical chart review or direct prospective examination. We sought to develop a less expensive and less time-consuming means of identifying postoperative complications that Professional Review Organizations (PROs) or similar entities could use to screen for potentially problematic hospitals or surgeons. In this

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article, we describe a methodology for identifying complications following carotid endarterectomy, using physician claims.

METHODS

DATA

Medicare hospital (MedPAR) claims were used to identify all patients undergoing carotid endarterectomy (ICD-9 code 38.12) between January 1, 1991 and November 31, 1991. From these claims, we selected a random 20 percent sample of patients ($n = 8{,}345$). We excluded patients who were not eligible for Part B, or who were enrolled in HMOs, as Part B claims would not be available for these patients (Mitchell, Bubolz, Paul, et al. 1994). All Medicare records for sample patients then were extracted from the date of admission through 30 days following surgery. These included the 1991 denominator file (containing information on patient demographic characteristics and date of death, if applicable), and claims for acute care hospitals, long-term hospitals, skilled nursing facilities (SNFs), home health care, outpatient departments, physicians, and other suppliers. In addition, we extracted all MedPAR records with a principal diagnosis of cerebral infarction from the previous three years (1988–1990).

DEFINING POSTOPERATIVE COMPLICATIONS

Neurologists participating in the Stroke Prevention PORT identified the following services as indicative of complications resulting from carotid endarterectomy if they were provided within 30 days of surgery: head CT, head MRI, and surgical exploration of the neck for hemorrhage, thrombosis, or infection. The latter is self-explanatory, as re-operation of the wound site clearly indicates postoperative morbidity. Head CT and head MRI, on the other hand, are diagnostic studies, often performed *prior to* carotid endarterectomy. Subsequent to surgery, these tests would be used primarily to evaluate a decline in neurologic status during the postoperative period. We identified these three types of services from Medicare Part B (physician) claims, based on CPT-4 procedure codes. From these bills, we can determine the date of service and link them to the date of surgery. Because we cannot distinguish preoperative from postoperative CT and MRI scans when provided on the same day as the endarterectomy itself, all scans on the date of surgery were assumed to be preoperative. This may result in a small underestimate of postoperative complications.[1]

We initially had considered using postoperative cerebral angiography as an additional indicator of complications. We rejected this for two reasons: (1) relatively few patients receive this procedure following carotid endarterectomy (2.6 percent in our study), and (2) some surgeons perform postoperative angiography to confirm arterial patency even when there is no evidence of complications.

STATISTICAL METHODS

We used two types of measures–outcomes and costs–to validate our methodology. Outcomes included 30-day mortality, hospital length of stay, discharge to an institution (rehabilitation or other long-term hospital, SNF, or nursing home), and readmission to an acute care hospital within 30 days of surgery. Costs were calculated from all claims associated with the hospitalization and the 30-day postoperative period. All facility charge data were converted to costs, using the cost-to-charge ratios calculated from each institution's Medicare Cost Report. These cost reports were obtained for acute care hospitals, rehabilitation and other PPS-exempt hospitals, and SNFs. No such cost-reporting data are available for other Medicare services (such as physicians); we simply used Medicare's allowed payments for these cases. Finally, all costs were then adjusted for geographic price differences using the PPS Wage Index.

The characteristics of patients with and without complications were compared using *t*-tests for continuous variables and chi-square tests for categorical variables. Because certain types of hospitals or certain surgical specialties may get relatively more complex cases than others, logistic regression analysis was used to adjust for all of the patient characteristics (available on claims data) that might affect outcome differences. Patient covariates included: age, gender, race, the six comorbid conditions, whether the patient was transferred from another acute care hospital, whether the patient originally became Medicare-eligible because of disability, and history of stroke or TIA (transient ischemic attack) admissions in the six months prior to surgery. In addition, we adjusted for hospital teaching status, urban/rural location, and specialty of the surgeon. (Surgeons were identified from the Part B claim submitted for the carotid endarterectomy.) Adjusted complication rates by surgical specialty and hospital type were calculated by evaluating all covariates at the sample mean, and "turning on" the appropriate indicator variable. Thus, adjusted complication rates for general surgeons and neurosurgeons assume that both of these surgical specialties treat the same patient mix and practice in the same types of hospitals.

RESULTS

Using our methodology, one out of every ten endarterectomy patients (10.3 percent) was identified as having had surgical complications (see Table 1), a rate comparable to those found in studies based on medical record abstraction (Brook, Park, Chassin, et al. 1990). The majority of complications were identified by the use of postoperative CT scans. The percentages shown in Table 1 do not sum to 10.3 percent, because some patients received more than one procedure.

OUTCOMES AND COSTS

If our methodology of using physician claims to identify patients with postoperative complications is valid, then such patients should experience worse outcomes and incur higher costs, compared with patients not suffering complications. From Table 2, we see that this is, in fact, the case. Patients with complications stay in the hospital almost twice as long: 12.7 days compared with only 6.4 days for other endarterectomy patients. Once discharged, furthermore, they are significantly more likely to be discharged to an institutional setting, such as a rehabilitation hospital or nursing home, suggesting that their neurologic and/or functional status is relatively more impaired. Readmission rates also are significantly higher; patients with surgical complications are more than three times as likely to be readmitted to acute care hospitals.

Finally, patients with complications are eight times more likely to die within 30 days of their surgery. Almost 9 percent (8.9 percent) died, compared with only 1.1 percent of those endarterectomy patients not experiencing complications.

Not surprisingly, given their long hospital stays and greater use of post-acute care services, patients with complications are significantly more expensive to treat. Total costs of treatment (from the day of admission through

Table 1: Identifying Complications of Carotid Endarterectomy (30 Days Postoperative)

Patients Receiving	*% of All Patients*
Postoperative CT scan	8.9%
Postoperative MRI scan	1.0
Re-operation, neck, for hemorrhage, thrombosis, infection	1.0
Any of the above	10.3

Source: 20 percent sample of Medicare patients admitted for carotid endarterectomy from January 1–November 30, 1991.

Table 2: Outcomes and Costs for Carotid Endarterectomy Patients with and without Postoperative Complications

	With Complications	*No Complications*
Outcomes		
Length of stay (in days)	12.7**	6.4
Discharged to an institution (%)	24.9**	2.9
30-day readmission rate (%)	26.8**	8.2
30-day mortality (%)	8.9**	1.1
Costs		
Hospitalization	$13,005**	$6,892
Inpatient physician services	4,123**	2,905
Post-acute care	5,059**	1,094
Total	22,187**	10,892

**Significantly different from those with no complications at the .01 level.

Source: 20 percent sample of Medicare patients admitted for carotid endarterectomy from January 1–November 30, 1991.

30 days postoperative) were double for patients experiencing surgical complications: $22,187 compared with only $10,892 for carotid endarterectomy patients who did not develop complications.

PATIENT CHARACTERISTICS AND COMORBIDITY

It is possible that our sample of carotid endarterectomy patients already were at greater risk prior to surgery. If so, we could detect few differences based on claims data. Complication rates did not vary by patient age, gender, or race (Table 3). The absence of any difference by age is somewhat surprising, given that the risk of postoperative complications has been shown to rise dramatically with age, even among the elderly (Fisher, Malenka, Solomon, et al. 1989; McCrory, Goldstein, Samsa, et al. 1993).[2]

Patients with a history of prior stroke may be at greater risk for complications as a result of any residual neurologic deficits. Table 4 compares complication rates for patients with a hospital admission for either cerebral infarction or TIA within the six months prior to surgery. Although complication rates were higher for patients with either prior cerebrovascular admissions, they were not significantly different from those for patients without such admissions.

We also sought to identify comorbid illness that might be indicative of increased operative risk among carotid endarterectomy patients. Table 4 also displays the frequency distribution of Charlson Index scores (as adapted

Table 3: Postoperative Complication Rates by Sociodemographic Characteristics of Carotid Endarterectomy Patients

	(N *of Complications,* N *of Cases)*	*Complication Rate*
Age		
65–69	(232, 2302)	10.1%
70–74	(250, 2542)	9.8
75–79	(241, 2230)	10.8
80 and over	(140, 1272)	11.0
Sex		
Male	(478, 4623)	10.3%
Female	(385, 3723)	10.3
Race		
White	(802, 7786)	10.3%
Black	(23, 194)	11.9
Other	(13, 102)	12.8
Unknown	(25, 264)	9.5

Source: 20 percent sample of Medicare patients admitted for carotid endarterectomy from January 1–November 30, 1991.

by Deyo, Cherkin, and Ciol 1992 for use with administrative data) for our two groups of patients. The Charlson Clinical Comorbidity Index is the sum of selected chronic conditions (reported as secondary diagnoses) shown to be associated with poor outcomes. No significant differences in complication rates based on Charlson Index scores were found.

The Charlson Index was originally developed from a cohort of medical (unspecified) patients and then tested in a cohort of breast cancer patients (Charlson et al. 1987). It was later adapted for use with claims data and validated on a sample of patients undergoing lumbar spine surgery (Deyo, Cherkin, and Ciol 1992). In order to better capture comorbidity specifically associated with cerebrovascular disease, neurologists participating in the Stroke PORT identified six comorbid conditions–hypertension, congestive heart failure, diabetes mellitus, old myocardial infarction,[3] chronic obstructive pulmonary disease, and valvular heart disease–expected to increase the risk of poor outcomes specifically for patients undergoing carotid endarterectomy. (It should be noted that all but two of these six diagnoses, hypertension and valvular heart disease, also are included in the Charlson Index.) The percentage of patients with each of these six conditions is also shown in Table 4. Although we do observe differences between the two groups, they

Table 4: Postoperative Complication Rates by Comorbidity Status of Carotid Endarterectomy Patients

	(N *of Complications,* N *of Cases)*	*Complication Rate*
Stroke Admission in Past Six Months		
Yes	(18, 145)	12.4%
No	(845, 8200)	10.3
TIA Admission in Past Six Months		
Yes	(5, 32)	15.6
No	(858, 8313)	10.3
Charlson Index Score		
0	(585, 5734)	10.2
1	(235, 2299)	10.2
2+	(43, 313)	13.7
Presence of Comorbid Conditions		
Hypertension**		
Yes	(268, 3285)	8.2
No	(595, 5060)	11.8
Congestive heart failure**		
Yes	(62, 349)	17.8
No	(801, 7996)	10.0
Diabetes mellitus		
Yes	(146, 1395)	10.5
No	(717, 6950)	10.3
Old myocardial infarction*		
Yes	(17, 274)	6.2
No	(846, 8071)	10.5
COPD		
Yes	(121, 1062)	11.4
No	(742, 7283)	10.2
Valvular heart disease		
Yes	(8, 64)	12.5
No	(855, 8281)	10.3

*Significant at .05 level.

**Significant at .01 level.

Source: 20 percent sample of Medicare patients admitted for carotid endarterectomy from January 1–November 30, 1991.

are not always in the expected direction. Complication rates were significantly higher among patients with congestive heart failure, but they were significantly lower among those with either hypertension or an old MI. The

difference in complication rates for patients with and without hypertension should be interpreted with caution, however, given the apparent systematic under-reporting of this chronic condition in hospital claims (Iezzoni, Foley, Heeren, et al. 1992; Jencks, Williams, and Kay 1988).

HOSPITAL AND PHYSICIAN CHARACTERISTICS

We also examined where carotid endarterectomies were being performed and by whom (Table 5). Hospitals were classified by teaching status into four categories: (1) academic medical centers, as defined by the Association of American Medical Colleges; (2) other Council of Teaching Hospitals (COTH) hospitals; (3) all other teaching hospitals; and (4) non-teaching hospitals. Complication rates did vary by hospital teaching status, although the absolute differences were relatively small. Inexplicably, "other" teaching (non-COTH) hospitals had slightly lower complication rates compared with other hospitals.

There were no significant differences by urban/rural location of the hospital. Similarly, no differences in postoperative complication rates were found related to the specialty of the surgeon performing the endarterectomy.[4]

DISCUSSION

A potential criticism of our measure of complications is that it will be sensitive to access to, and propensity to use, CT and MRI scanners. Actual complication rates could be underestimated in hospitals without such equipment, and overestimated in hospitals with medical staff more likely to order such tests. We believe any such bias is small for two reasons. First, we linked American Hospital Association (AHA) survey data to our hospital claims to determine equipment availability at our sample hospitals. Almost all carotid endarterectomy patients were treated in hospitals that had CT scanners (96.0 percent), with no significant differences in availability between those with and without complications (96.3 percent and 96.9 percent, respectively).[5] Similarly, there were no differences in the availability of MRI scanners; while the majority of patients with postoperative complications were treated in hospitals with this technology (82.7 percent), so were those without complications (83.4 percent). Second, while we could not directly measure the propensity to use technology, we did have some proxies, namely, hospital teaching status and surgical specialty. If physicians in major teaching hospitals are more likely to order tests, as commonly believed, we might have expected to observe

Table 5: Postoperative Complication Rates by Hospital and Surgeon Characteristics of Carotid Endarterectomy Patients

	(N of Complications, N of Cases)	Complication Rate	
		Unadjusted	Adjusted†
*Hospital Teaching Status**			
Academic medical center	(59, 495)	11.9%	11.2%
Other COTH	(103, 942)	10.9	10.4
Other teaching	(269, 2909)	9.2	8.9
Nonteaching	(430, 3992)	10.8	10.6
Hospital Location			
Urban	(767, 7385)	9.9	10.0
Rural	(94, 954)	10.4	9.5
Specialty of Surgeon			
General surgery	(372, 3874)	9.6	9.3
Neurological surgery	(63, 546)	11.5	11.0
Cardiac/Thoracic surgery	(318, 2942)	10.8	10.5
Other surgical specialty‡	(63, 497)	12.7	12.0
None	(47, 487)	9.7	9.4

*Significant at .05 level.

†Adjusted for patient's age, gender, race, comorbidity, transfer status, disability, six-month history of stroke or TIA admissions, hospital teaching status, location, and surgeon specialty.

‡Includes multispecialty group.

Source: 20 percent sample of Medicare patients admitted for carotid endarterectomy from January 1–November 30, 1991.

higher complication rates in those facilities. In fact, no such differences were found.

Prior research on adverse outcomes has sought to predict postoperative complications of carotid endarterectomy in order to better understand the factors that place a patient at increased surgical risk. When the risks of surgery outweigh the risks of a possible stroke, then carotid endarterectomy will be contraindicated for that patient (Beebe, Clagett, DeWeese, et al. 1989; Matchar and Pauker 1987). Our focus was not on predicting complications for individual patients, but rather on developing a methodology to screen for potential quality of care problems.

Our findings suggest that Part B physician claims may provide a relatively effective means of identifying postoperative complications. Few differences in complication rates were attributable to patient risk factors, suggesting that postoperative complications were unrelated to, and could not have been

predicted by, other clinical characteristics at the time of admission. (We refer, of course, just to those clinical risk factors available on claims data.) PROs or other quality assurance organizations could use this approach as a screen for problem surgeons or problem hospitals. Before its widespread dissemination as a screening tool, however, it should be clinically validated. This could be done through medical chart abstraction coupled with prospective assessment of the neurological status of patients following carotid endarterectomy.

NOTES

1. In our sample, however, all patients with either CT or MRI on the day of surgery ($n = 189$) would have been identified as having postoperative complications anyway (i.e., they also experienced postoperative surgical exploration of the neck and/or received a second CT or MRI scan sometime after the day of surgery).
2. By contrast, Brook, Park, Chassin, et al. (1990) failed to find any relationship between patient age and complication rate. The reasons for the discrepancy are not clear. Both the Fisher and Brook studies were limited to patients aged 65 and older, while the McCrory study examined a relatively young group of patients (mean age of 67). The Fisher study was limited to administrative data only, on the other hand, while the Brook and McCrory studies both included detailed clinical data, obtained from medical chart abstraction.
3. Acute myocardial infarction (AMI) was not included on the assumption that carotid endarterectomy would never be performed on patients admitted with an AMI, and that any AMI listed on the hospital claim would have occurred following surgery.
4. There was no Part B surgeon's bill found for a small proportion of patients in both groups. Previous research has found that these cases were generally treated in teaching hospitals (Mitchell 1985); presumably, a resident (who is not permitted to bill Medicare) performed the procedure. It should be noted that physician specialty on Medicare claims is self-designated (by the physician). Unfortunately, in 1991, Medicare did not have a separate specialty code for vascular surgery.
5. Some hospitals did not answer the AHA survey questions on availability of scanning technology. These hospitals treated 3.9 percent of the carotid endarterectomy patients in our sample. There were no differences in this nonresponse rate between patients with and without complications, however.

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