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Hospital resource use following carotid endarterectomy in 2006: analysis of the Nationwide Inpatient Sample

KC Young, PhD, MPH^{1,2,*}, BS Jahromi, MD, PhD^{3,4}, MJ Singh, MD², KA Illig, MD², and CG Benesch, MD, MPH^{1,3}

¹ Department of Neurology, University of Rochester School of Medicine and Dentistry. Rochester, New York, USA

² Department of Surgery, University of Rochester School of Medicine and Dentistry. Rochester, New York, USA

³ Department of Neurosurgery, University of Rochester School of Medicine and Dentistry. Rochester, New York, USA

⁴ Department of Imaging Sciences, University of Rochester School of Medicine and Dentistry. Rochester, New York, USA

Abstract

Introduction—Our objective was to outline the relationship between age and length of stay (LOS), hospital costs and discharge disposition following carotid endarterectomy (CEA).

Materials and Methods—We identified discharge records from the 2006 Nationwide Inpatient Sample (NIS). The primary outcome was LOS from the surgical procedure to discharge. We examined LOS from procedure to discharge because the time from procedure to discharge may better reflect hospital stay due to the procedure itself for subjects with symptomatic carotid artery disease rather than including days hospitalized for stroke recovery. Secondary endpoints included total LOS, discharge disposition and hospital costs.

Results—There were 118,218 discharge records for CEA and >90% were for asymptomatic carotid disease. The LOS from procedure to discharge and total LOS increased per decade starting with the age range of 70–79 years. Age per decade increased the likelihood of requiring a LOS from procedure to discharge of >1 day. The same trend was seen for requiring a >2 day post-operative stay. Those age ≥80 years required longer post-operative LOS compared to younger ages (OR=1.45 for >1 day and OR=1.45 for >2 days, both $p<0.001$). Total hospital costs averaged \$10,965 for all discharges. For age dichotomized at 80 years, the average cost increased by \$845. Also, age ≥80 years was independently associated with discharge to a skilled nursing facility (OR=2.4, 95% CI=2.09–2.76).

Discussion—Increased hospital LOS and costs were required following CEA as age increased. Morbidity following CEA should be discussed with subjects considering revascularization for asymptomatic disease.

*Corresponding Author: Kate C. Young, PhD, MPH, URM Stroke Center, 601 Elmwood Ave, Box 681, Rochester, NY 14642, Phone: (585) 275-5091, Fax: (585)273-1026, kate_young@urmc.rochester.edu.

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INTRODUCTION

Clinical trials show that carotid endarterectomy (CEA), when added to medical management, reduces the risk of future stroke.[1,2] However, the role of age in relation to hospital resource use for CEA remains ill-defined. NASCET initially excluded octogenarians with severe symptomatic stenosis. Those age ≥ 80 years with moderate symptomatic stenosis could be enrolled in NASCET beginning in 1991.[1] ACAS limited the age of subjects to 40–79 years.[2] Recent studies of carotid artery stenting in high risk individuals listed age ≥ 80 as a factor indicative of high surgical risk.[3,4] Current data are needed to broadly assess the burden of an age on hospitals that will provide CEA in greater numbers as the US population ages.

A previous analysis of US hospital discharges from the Nationwide Inpatient Sample (NIS) showed a non-significant increase for in-hospital mortality and stroke in older age categories.[5] One limitation in this study was that age ≥ 70 year old represented the oldest age category. In light of recent trends, age per decade and age ≥ 80 years should be considered for analysis. Also, hospital charges have been reported for CEA as a measure of resource utilization.[5] However, charges do not reflect the hospital reimbursement by Medicare or other payers. Additionally, hospital and health care resource use can be measured as length of stay and discharge disposition.

The purpose of this study is to delineate the relationship between age and health care resource use at discharge following CEA. Specifically, we use the 2006 NIS to analyze age per decade and age ≥ 80 years in relation to length of stay following the procedure, hospital costs and discharge disposition, as indicators of health care resource use. Analyzing the number of days from the day of the CEA to discharge provides an estimate of resource utilization for the surgical procedure itself. Total length of stay includes stroke recovery for symptomatic subjects and could confound the analysis of resource use. Utilization is also measured as hospital costs (determined by cost-to-charge ratios within the NIS), which reflect operating and capital-related costs. Discharge disposition represents health care utilization immediately after hospital discharge.

METHODS

NIS overview

The 2006 Nationwide Inpatient Sample (NIS) is a stratified sample representing 20% of all US discharges from non-federal hospitals.[6] The NIS is designed to provide nationwide estimates of health care resource use. For data quality reports and comparison reports addressing the accuracy of the NIS, please see:

<http://www.hcup-us.ahrq.gov/db/nation/nis/nisrelatedreports.jsp>. The NIS includes multiple payers, hospital types (teaching and non-teaching), location (urban and rural) and size (based on available beds). The NIS was trimmed by searching for discharge records containing the procedure code for CEA (ICD-9 code 38.12) and by cross-referencing with discharge codes for occlusion or stenosis of the precerebral arteries (433.10–1 and 433.30–1). Comorbidities were identified using the clinical classification software and included renal failure, myocardial infarction, hypertension, diabetes, chronic obstructive pulmonary disease, congestive heart failure, and valve disease.[7] Tobacco use or history of tobacco use was identified using ICD-9 diagnostic codes 305.1 or V15.82, respectively. ICD-9 diagnosis codes were also used to define symptom status (transient ischemic attack, TIA: 435.9 or 362.34, infarction: 433.11 or 433.31), contralateral stenosis or occlusion (433.30 or 433.31), and post-operative stroke (997.02).

Primary analysis

The primary outcome was length of stay from procedure to discharge. Time from procedure to discharge was calculated as the total length of stay minus the number of days from admission to procedure. Total length of stay was considered as a secondary endpoint. Time from procedure to discharge is a better reflection of resource use attributed to the actual carotid endarterectomy procedure itself, whereas total length of stay includes hospital days between admission and procedure for symptomatic individuals. Records with missing data or a negative time from procedure to discharge were excluded from the primary analysis.

Secondary analyses

Total length of stay, hospital costs and discharge disposition were studied as secondary analyses. Hospital costs were calculated from the group average all-payer inpatient cost-to-charge ratio using the 2006 files. Finally, discharge disposition was analyzed to assess the likelihood that octogenarians were more often discharged to skilled nursing or other intermediate care facilities (SNF).

Statistical methods

Analysis of the primary and secondary outcomes used sample-weighted multivariate regression to control for hospital-level factors and comorbidities (SAS 9.1, Cary, NC). Chi-squared analyses were used for contingency tables. Student's t-tests were used for continuous variables.

RESULTS

NIS subject characteristics

The 2006 NIS had 118,218 discharge records that include the procedure code for CEA. The average age was 71 (range 32–98) and 19.5% of the cohort was at least 80 years of age. Demographics and health history for these records are listed in Table 1. A sample size of 99,421 was used for evaluating length of stay from the procedure to discharge (16% of the records had incomplete or missing data for this outcome).

Age in relation to length of stay

The average number of days from CEA to discharge was constant per decade from age 40–69 years and increased with each decade of life beginning at age 70 (Fig 1A). Length of stay from procedure to discharge was 1.9–2.0 days for 40–69 year olds. It was 2.2 days, 2.5 days and 2.9 days for the decades of 70–79, 80–89 and 90–99, respectively. The number of days from CEA to discharge for 30–39 year old individuals was also increased.

Forty-four percent of the discharge records had a length of stay after CEA of greater than one day. Starting at an age of 70, the odds of requiring a post-operative hospitalization of greater than one day increased per decade (compared to 60–69 year olds, Table 2). This association persisted when post-operative stroke was included as a confounding factor. Those with symptomatic stenosis (TIA or infarct) were also more likely to have a longer stay. Female gender, non-white race, comorbidities, post-operative stroke and hospital bed size were also associated with increased post-operative stay. Using multivariate regression to control for the factors listed in Table 2 with an age cut-off of 80 years, those over 80 were also more likely to require a length of stay after CEA of greater than one day (OR=1.45, 95% CI 1.35–1.56, $p < 0.001$).

A length of stay from CEA to discharge of two days was tested as a secondary endpoint because it was the median value for those over the age of 80 (Table 2). This two-day endpoint reflected nineteen percent of the discharge records. Again, the likelihood of having a postoperative stay

longer than two days increased per decade of age starting at 70 years (Table 2). Symptom status, gender, non-white race, comorbidities and hospital size were also significantly associated with increased length of stay after CEA. Octogenarians were also more likely to require more than two days of hospitalization after CEA (OR=1.44, 95% CI 1.32–1.57, $p<0.0001$).

Total length of stay for the hospitalization decreased as age increased from 30 to 69 (Fig 1B). Total hospital length of stay increased as age increased beginning at age 70.

Health care resource use

Total hospital costs for CEA in 2006 averaged \$10,965 per discharge record (SE: \$80, maximum: \$290,700). Hospital costs decreased to \$10,800 (SE: \$86, maximum: \$290,700) for those under 80 and were \$11,645 (SE: \$204, maximum: \$265,500) for octogenarians (Table 3). Those age ≥ 80 years required an extra 0.4 days of hospitalization between the procedure and discharge ($p<0.0001$ vs. non-octogenarians). Total length of stay increased 0.7 days for those ≥ 80 years of age ($p<0.0001$ vs. non-octogenarians).

An increased proportion of octogenarians were discharged to SNFs or home health care compared to the younger cohort (Table 3). For comparison, 0.6% and 0.7% of those age <80 and age ≥ 80 years, respectively, were admitted from another facility, including SNFs. After multivariate analysis including admission source, symptom status, post-operative stroke and comorbidities the odds ratio (OR) of being discharged to a SNF for octogenarians was 2.4 (95% CI: 2.09–2.76; Table 4).

Age in relation to post-operative stroke and in-hospital mortality

Ages of 80 and older were not associated with the combination endpoint of in-hospital stroke or death (95% CI: 0.93–1.59). Age ≥ 80 was also not associated with increased odds of post-operative stroke. The 95% confidence interval for the OR was 0.72–1.40 ($p=0.99$) when controlling for comorbidities, cohort characteristics and hospital characteristics (Table 3). However, age ≥ 80 years was associated with an increased likelihood of in-hospital mortality (OR=1.6, 95% CI: 1.04–2.46, $p<0.04$).

DISCUSSION

Health care resource use measured at discharge following CEA increases with age. Length of stay after CEA increases independently per decade starting at 70–79 years. Age dichotomized at 80, a typical age cut-off for high surgical risk, was also associated with increased post-operative length of stay, hospital costs and discharge to a SNF. In addition to age, comorbid conditions also increased health care utilization. However, increased health care resource use was not due to increased post-operative stroke in octogenarians.

We confirmed an association between age dichotomized at 80 years and in-hospital mortality.[8] We found no significant association between age per decade or age dichotomized at 80 years and in-hospital post-operative stroke. This finding is consistent with an analysis of the 2005 NIS which also failed to identify an association of age, when divided into three levels (<60 , 60–69, >70), and post-operative stroke.[5] Lastly, a systematic review showed no increase in peri-operative stroke with increasing age.[9] There was no association between age and the combined endpoint of in-hospital post-operative stroke or mortality. This analysis extends an observation that stroke or MI rates after CEA were higher in black subjects by demonstrating greater in-hospital resource use among those of non-white race.[10]

Disease etiology may explain the u-shaped relationship between the length of stay from procedure to discharge and age. Carotid artery disease at younger ages may represent extreme

atherosclerosis, familial hypercholesterolemia, or thrombus evacuation. Previously, individuals <50 years who underwent CEA were more likely to be smokers, have low HDL levels or consume alcohol.[11,12] However, the increased time from procedure to discharge for 30–39 year olds compared to the 60–69 age group did not reach statistical significance (Table 3).

The data have the following limitations. The outcomes analysis is limited to the duration of the hospital stay. Use of 997.02 as the ICD-9 code for post-operative stroke, or codes for tobacco use may not be consistent between hospitals, thus in-hospital post-operative stroke may be under-represented. This analysis does not account for 30-day morbidity and mortality or duration of SNF admission. Analyzing hospital charges is not an accurate reflection of the cost to the health care system. We compensated for this shortcoming using cost-to-charge ratios. Hospital payments reflect operating and capital costs better than charges. Two similar hospitals based on location, size and teaching status may have radically different charges but receive similar Medicare payments as cost-to-charge ratios ranged from 19.9% to 95.8%.

The proportion age of 80 and older discharged to SNFs is intriguing. The percent of subjects admitted from such a facility did not vary with age and neither did the post-operative stroke rate. For those subjects age 80–98: 4.3% had an infarct yet were considered healthy enough for CEA; 1% had a post-operative stroke; and <1% came from a SNF. Assuming no overlap, this 5.3% did not equal the 9.7% of subjects that were discharged to a SNF. The increased odds of discharge to a SNF were independent of comorbidities, post-operative stroke, symptom status and admission source. On the other hand, over 90% of the procedures were for asymptomatic stenosis, regardless of age. An additional 4.1% of subjects age 80 and older compared to younger subjects (9.8% versus 5.7%, respectively) were discharged with home health care. Thus, reinforcing the question of why was discharge disposition different for older subjects?

The increased likelihood of discharge to an SNF for subjects ≥ 80 years of age reflects some type of increased post-operative morbidity or pre-existing health condition that could not be identified by this analysis. Moreover, ACST illustrated that older individuals, defined by an age cut-off of 75 years ($n=650$ subjects ≥ 75), would not likely benefit from immediate CEA. [13] AAN guidelines reflect this position, recommending asymptomatic CEA for those 40–75 years.[14] Possible explanations for these findings may include that stroke severity, postoperative myocardial infarction or other hospital acquired conditions increase with age. Stroke severity was not part of the NIS and could not be analyzed. Nevertheless, the potential for increased morbidity must be addressed with octogenarians considering prophylactic endarterectomy for asymptomatic stenosis.

Age is associated with increased health care resource use following CEA, including longer length of stay, higher costs and increased likelihood of being discharged to a SNF. Resource planning must ensure sufficient hospital beds for aging sick populations, sufficient skilled nursing or intermediate care beds, sufficient home health care and sufficient dollars for operating costs to meet the needs of an aging population.

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Figure 1A

Figure 1B

Figure 1.

A) Average length of stay (LOS) from procedure to discharge (days) per decade of life. LOS from procedure is calculated as total LOS minus the number of days between admission and procedure. n=99,421, where this endpoint is non-negative or not missing. B) Average LOS, in total, per decade of life. n=118,218.

Table 1

Carotid endarterectomy patient characteristics, 2006.

	Overall	<80 years	80+ years
No. admissions (%)	118,218 (100)	95,157 (80.5)	23,052 (19.5)
Age (y)			
Mean [SEM]	71 [0.06]	68 [0.06]	83.5 [0.04]
Range	32–98		
30–39, no. (%)	114 (0.1)		
40–49	1,762 (1.5)		
50–59	12,714 (10.8)		
60–69	34,582 (29.3)		
70–79	45,985 (38.9)		
80–89	22,062 (18.7)		
90–99	990 (0.8)		
Gender			
% Male	57.4	58.3	53.9
Race, %			
Non-white	34.3	35.1	31.4
White	65.6	64.9	68.6
Symptom status*			
Asymptomatic	91.6	91.6	91.6
Symptomatic	8.4	8.4	8.4
TIA	4.4	4.5	4.1
Infarction	4.0	3.9	4.3
Comorbid conditions, %			
Renal failure	4.6	4.1	6.3
Myocardial infarction	49.0	49.0	49.3
Congestive heart failure	7.8	7.1	10.6
COPD	18.9	19.6	16.1
Diabetes	30.1	31.4	25.0
Hypertension	78.6	78.5	79.2
Valve disease	8.5	7.4	13.1
Tobacco use, or history	34.6	38.4	19.2
Hospital type, %			
Non-teaching	55.3	54.6	58.4
Teaching	44.6	45.3	41.5
Hospital bed size, %			
Small	11.9	11.7	12.9
Medium	23.3	23.3	23.5
Large	64.7	65.0	63.6
Payer, %			
Private	21.8	26.1	3.9
Medicare	72.9	67.6	95.1

	Overall	<80 years	80+ years
Medicaid	2.4	2.9	<0.5
Self-pay/Other	2.9	3.4	<1.0

* Symptom status: Asymptomatic subjects are those without diagnosis codes for TIA or infarction. Numbers and percentages may not total 100% because of rounding or missing data. TIA: transient ischemic attack; COPD: chronic obstructive pulmonary disease.

Table 2

Multivariate analysis of LOS from procedure to discharge, >1 day vs. 1 day or >2 days vs. 1–2 days. TIA: transient ischemic attack; COPD: chronic obstructive pulmonary disease.

	Procedure to discharge >1 day vs. 1 day			Procedure to discharge >2 day vs. 1–2 days		
	OR	95% CI	P	OR	95% CI	P
Age			<0.0001			<0.001
30–39 vs. 60–69	1.09	0.39–3.07		0.71	0.21–2.45	
40–49 vs. 60–69	0.97	0.76–1.23		0.95	0.68–1.31	
50–59 vs. 60–69	0.94	0.84–1.04		0.97	0.84–1.12	
60–69, Reference						
70–79 vs. 60–69	1.12	1.04–1.20		1.11	1.01–1.22	
80–89 vs. 60–69	1.5	1.38–1.64		1.47	1.32–1.64	
90–99 vs. 60–69	2.35	1.69–3.26		2.89	2.03–4.05	
Symptoms			<0.0001			<0.001
Infarct (vs. asymptomatic)	4.4	3.72–5.22		4.29	3.67–5.02	
TIA (vs. asymptomatic)	1.67	1.46–1.91		1.87	1.6–2.2	
Gender (female vs. male)	1.43	1.35–1.52	<0.0001	1.31	1.21–1.41	<0.001
Race (white vs. other)	0.75	0.7–0.79	<0.0001	0.78	0.72–0.85	<0.001
Comorbidities						
Contralateral stenosis	1.13	1.04–1.22	<0.003	1.26	1.14–1.38	<0.001
Renal failure	2.54	2.18–2.95	<0.0001	2.99	2.58–3.47	<0.001
Myocardial infarction	1.21	1.14–1.28	<0.0001	1.32	1.23–1.43	<0.001
Congestive heart failure	1.62	1.44–1.81	<0.0001	2.29	2.03–2.58	<0.001
COPD	1.52	1.41–1.64	<0.0001	1.6	1.46–1.75	<0.001
Diabetes	1.17	1.09–1.24	<0.0001	1.19	1.1–1.29	<0.001
Hypertension	1.12	1.05–1.21	<0.002	1.0	0.92–1.1	NS
Valve Disease	1.33	1.20–1.48	<0.0001	1.73	1.54–1.94	<0.001
Tobacco	0.78	0.73–0.83	<0.0001	0.69	0.63–0.75	<0.001
Post-op stroke	55.8	20.6–151	<0.0001	47.3	27.6–81.3	<0.001
Hospital teaching status						NS
Teaching (vs. non-teaching)	1.02	0.97–1.08	NS	1.03	0.96–1.12	
Hospital Bed size			<0.0005			<0.001

	Procedure to discharge >1 day vs. 1 day			Procedure to discharge >2 day vs. 1-2 days		
	OR	95% CI	P	OR	95% CI	P
Large (vs. small)	1.18	1.08-1.30		1.39	1.22-1.58	
Medium (vs. small)	1.24	1.12-1.37		1.26	1.1-1.46	

Table 3

Univariate analysis of resource utilization for those ≥ 80 years of age and younger individuals. SNF: skilled nursing facility. LOS: length of stay.

	Overall	<80	80+	<i>P</i>
Total hospital cost, mean [SEM]	\$10,965 [80]	\$10,800 [86]	\$11,645 [204]	<0.001
LOS, procedure to discharge				
Mean [SEM]	2.1 [0.02]	2.1 [0.02]	2.5 [0.06]	<0.001
Median	1	1	2	
Range	0–94	0–70	0–94	
LOS, total				
Mean [SEM]	2.9 [0.03]	2.8 [0.03]	3.5 [0.07]	<0.001
Median	1	1	2	
Range	0–99	0–80	0–99	
Discharge disposition, %				<0.001
routine	87.6	89.6	79.2	
SNF, intermediate care	5.1	4.0	9.7	
Home health care	6.5	5.7	9.8	

Table 4

Multivariate analysis for discharge to a skilled nursing facility (SNF). TIA: transient ischemic attack; COPD: chronic obstructive pulmonary disease; ED: emergency department.

	Discharge to SNF		
	OR	95% CI	P
Age			
80–99 vs. 30–79	2.4	2.09–2.76	<0.0001
Symptoms			<0.0001
Infarct (vs. asymptomatic)	2.99	2.38–3.75	
TIA (vs. asymptomatic)	0.9	0.67–1.22	
Gender (female vs. male)	1.26	1.1–1.43	<0.001
Race (white vs. other)	0.91	0.8–1.04	NS
Comorbidities			
Contralateral stenosis	1.24	1.05–1.45	<0.01
Renal failure	2.03	1.62–2.54	<0.0001
Myocardial infarction	0.95	0.83–1.08	NS
Congestive heart failure	2.09	1.73–2.52	<0.0001
COPD	1.56	1.33–1.82	<0.0001
Diabetes	1.21	1.05–1.39	<0.01
Hypertension	0.81	0.7–0.944	<0.01
Valve Disease	1.33	1.1–1.62	<0.01
Tobacco	0.57	0.48–0.66	<0.0001
Post-op stroke	34.6	24–648.7	<0.0001
Hospital teaching status			NS
Teaching (vs. non-teaching)	1.05	0.93–1.2	
Hospital Bed size			NS
Large (vs. small)	1.04	0.84–1.28	
Medium (vs. small)	1.14	0.9–1.44	
Admission Source			<0.0001
Another facility* vs. routine	16.0	10.7–24.1	
Another hospital vs. routine	4.52	3.3–6.2	
ED vs. routine	4.54	3.8–5.4	

* Admission from another facility including long-term care (LTC).