30-Day Survival and Rehospitalization for Stroke Patients According to Physician Specialty

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Key Words

Medicare data · Stroke outcome · Neurology care post stroke

Abstract

Background and Purpose: Stroke patients appear to have improved outcomes when cared for by neurologists, but the mechanism by which improved outcome is achieved is unclear. This study compares 30-day cause-specific rehospitalization, 30-day mortality, and specific processes of care for patients treated by a neurologist only, a generalist only, a neurologist and a generalist (i.e., collaborative care), or by another specialist during the index hospitalization. **Methods:** This study uses Cox regression to analyze claims and enrollment data from 44,099 Medicare beneficiaries 65 years of age and older and discharged with acute ischemic stroke from 1998 to 2000 in 11 US metropolitan regions. **Results:** Patients seen by neurologists had more severe strokes than patients seen by generalists, though patients seen by generalists had more comorbidities. Patients seen by neurologists (alone or collaboratively) had a 10 and 16% lower risk of 30-day mortality, respectively. Patients seen by a neurologist only had a 12% lower risk of rehospitalization for infec-

tions and aspiration pneumonitis. In contrast, patients seen by neurologists had a higher risk of rehospitalization for atherosclerotic (cardiovascular and non-acute cerebrovascular) disease. Patients seen by neurologists were more likely to be discharged to inpatient rehabilitation, had longer lengths of stay, and were more likely to receive warfarin after discharge. **Conclusions:** Results support the hypothesis that neurologists improve outcomes specifically by reducing the potential for aspiration (through increased swallowing evaluations) or by improving functioning (through use of rehabilitation therapy). Future studies should continue to examine the mechanisms by which neurologists may achieve better outcomes in stroke care.

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Introduction

Stroke patients appear to have improved mortality and reduced disability when cared for by neurologists during the inpatient hospitalization [1–4], but neurologists also perform more tests [1, 3] and are significantly more expensive [1]. The added value of neurology care for stroke patients continues to be hotly debated [5, 6]

and is fueled by the relative lack of studies identifying specific mechanisms through which care by a neurologist can be shown to improve outcomes such as mortality [7].

As pressure to contain the cost of health care increases, it is critical to begin understanding the organizational arrangements and mechanisms by which neurologists (alone or in collaboration with generalists) may achieve improved outcomes in stroke care [8]. Neurologists do have a different practice style when compared to generalist physicians [1, 3], including increased use of antiplatelets [3], occupational and speech therapy [3], anticoagulants [1], and discharge to inpatient rehabilitation facilities [1] as well as increased diagnostic testing [1, 3], and longer length of stay [1]. The goal of this study is to compare 30-day cause-specific rehospitalization, 30-day mortality, and specific processes of care for older stroke patients treated by a neurologist only, a generalist only, both a neurologist and a generalist, or by another specialist during the index hospitalization.

Methods

We identified 44,099 Medicare beneficiaries 65 years of age and older and discharged with acute ischemic stroke from 1998 to 2000 in 11 metropolitan regions based on an ICD-9 diagnosis code of 434 or 436 in the first position on the discharge diagnosis list. We obtained administrative data from the Centers for Medicare and Medicaid Services and from a large national health maintenance organization (HMO). Neurology care or generalist care (family practitioners, general practitioners, or internists) was identified by the presence of one or more claims during the index hospital admission. The dependent variables were the time (in days) from index hospital admission to death or rehospitalization (excluding admission to a rehabilitation facility or inpatient rehabilitation unit). Additional dependent variables representing the process of care included discharge destination, length of stay for the index admission, and warfarin use. Use of warfarin after discharge was proxied by claims for prothrombin time tests within 30 days after the stroke admission date (or prior to rehospitalization if rehospitalized within 30 days).

Primary diagnoses for the first rehospitalization within 30 days of the index admission date were categorized using Clinical Classification Software [9]. Control variables included individual sociodemographics, neighborhood socioeconomic (through Census 2000), HMO membership, comorbidities [10], mechanical ventilation [11], and placement/revision of a gastrostomy tube [12].

Cox regression was used to examine the relationship of physician specialty to 30-day rehospitalization and mortality. Because death is a competing risk for rehospitalization (i.e., patients cannot be rehospitalized after dying), patients who died were censored in the rehospitalization model at the date of death. Patients who were rehospitalized and subsequently died contributed to both the rehospitalization and mortality models. HMO patients who disenrolled were censored at their disenrollment date in rehospitalization mod-

els but not in mortality models (mortality data was available for HMO patients who disenrolled). Adjusted mean predicted probabilities and 95% confidence intervals were bootstrapped by replicating analyses 1,000 times. All statistical tests used robust variance estimates that allowed for clustering of patients within hospitals.

Results

Descriptive Characteristics

Patients seen by neurologists (either alone or collaboratively) had more severe stroke and those with collaborative care also had more comorbidities in addition to more severe stroke (table 1). Patients seen by a generalist only had more comorbidities and less severe stroke.

30-Day Mortality and Rehospitalization

Patients who were seen by a neurologist only or who had collaborative care had significantly lower 30-day mortality when compared to patients seen by a generalist only (table 2). Patients seen by a neurologist only also had a borderline lower risk of 30-day rehospitalization.

Cause-Specific 30-Day Rehospitalization

To examine specific mechanisms that might be associated with improved outcome, we examined cause-specific rehospitalization (table 3). Patients seen by a neurologist only had a significant 12% decreased risk of rehospitalization for infections and aspiration pneumonitis, but showed a significant 17% increased risk of rehospitalization for heart disease. In addition, patients with collaborative care had a significant 19% increased risk of rehospitalization for non-acute cerebrovascular disease. With the exception of an increased risk of rehospitalization for 'signs, symptoms, and ill-defined conditions' among patients with no physician claims, there were no other significant differences in the risk of rehospitalization.

Discharge Destination, Length of Stay, and Warfarin Use

Neurologists and generalists differed significantly in the process of care for stroke patients (table 4). After adjustment, patients who saw neurologists (either alone or collaboratively) were significantly more likely to be discharged to an inpatient rehabilitation facility when compared to patients who saw a generalist only, and patients who saw neurologists only were much less likely to be discharged to a skilled nursing facility. Patients who saw neurologists (either alone or collaboratively) also had

Table 1. Key characteristics of hospitalized acute stroke patients by neurology care category (n = 44,099)

Characteristic	Generalist only (n = 8,071)	Neurologist only (n = 7,408)	Collaborative care (n = 26,558)	Other specialist (n = 1,607)	No physician claims (n = 455)	p value
Sociodemographics						
Age, mean in years	82 (8)	79 (7)	80 (7)	80 (8)	80 (8)	<0.0001
Female	66	58	61	62	64	<0.0001
Caucasian	82	82	84	77	85	<0.0001
African-American	15	14	12	18	13	<0.0001
Other	2	4	4	5	2	<0.0001
Medicaid	19	14	16	18	15	<0.0001
HMO membership	12	14	9	27	22	<0.0001
% in block group below the poverty line, mean	0.12 (0.12)	0.12 (0.11)	0.11 (0.11)	0.13 (0.13)	0.12 (0.12)	<0.0001
% adults ≥25 years in block group with college degree, mean	0.23 (0.17)	0.24 (0.17)	0.24 (0.17)	0.22 (0.17)	0.21 (0.16)	<0.0001
Prior medical history						
Prior stroke	8	7	7	8	11	0.004
Cardiac arrhythmias	39	39	41	37	37	<0.0001
Congestive heart failure	27	22	24	25	25	<0.0001
Chronic pulmonary disease	20	18	20	20	17	0.003
Diabetes, uncomplicated	23	21	22	24	24	0.014
Diabetes, complicated	7	8	8	6	7	0.001
Hypertension	72	72	74	69	71	<0.0001
Fluid and electrolyte disorders	30	19	24	25	25	<0.0001
Valvular disease	14	17	17	15	13	<0.0001
Peripheral vascular disorders	16	14	15	16	13	0.002
Hypothyroidism	12	12	13	12	9	0.003
Solid tumor without metastasis	12	12	13	11	11	0.181
Deficiency anemias ^a	16	13	15	15	11	<0.0001
Depression	9	7	9	8	7	<0.0001
Dementia	28	20	22	23	26	<0.0001
Concurrent cardiac event	2	2	2	2	0	0.074
Disease severity						
Mechanical ventilation	2	4	4	2	1	<0.0001
Gastrostomy tube	6	5	9	5	2	<0.0001
Hemiplegia or hemiparesis	23	26	28	22	26	<0.0001
Residual neurological deficits	14	17	20	13	14	<0.0001

Values are expressed in percentages unless specified otherwise. Parentheses indicate standard deviations.

^a Includes anemias due to a nutritional deficiency (e.g., iron, vitamin B₁₂, folate, protein).

somewhat longer lengths of stay. Finally, patients who saw neurologists showed greater warfarin use after discharge.

Cause-Specific 30-Day Rehospitalization, Discharge Destination, and Warfarin Use

To evaluate whether discharge destination and warfarin use explained cause-specific 30-day rehospitalization, we included these variables in the rehospitalization models for infections and aspiration pneumonitis, heart dis-

ease, and non-acute cerebrovascular disease. Including discharge destination and warfarin use in the cause-specific rehospitalization models (above) did not explain the rehospitalization results for heart disease and non-acute cerebrovascular disease. However, in the model for infections and aspiration pneumonitis, the hazard ratio was no longer statistically significant after including discharge destination and warfarin use (hazard ratio = 0.90, 95% confidence interval 0.80, 1.02). This change was primarily related to the inclusion of discharge destination.

Table 2. Hazard ratios (HR) and 95% confidence intervals (CI) for the relationship between neurology care and 30-day mortality and rehospitalization (n = 44,099)

Category	Total n	30-day mortality			30-day rehospitalization		
		n	HR ^a	95% CI	n	HR ^a	95% CI
Generalist only	8,071	1,435	1.00		1,070	1.00	
Neurologist only	7,408	1,013	0.90	0.82, 0.998	882	0.91	0.82, 1.006
Collaborative care	26,558	3,914	0.84	0.79, 0.90	3,442	0.95	0.88, 1.04
Other specialist	1,607	300	1.17	1.02, 1.35	214	1.05	0.89, 1.24
No physician claims	455	86	1.01	0.75, 1.35	81	1.58	0.92, 2.70

^a Adjusted for age, female, race, Medicaid, % of the census block group aged ≥ 25 years with college degrees, % of persons in the census block group below the poverty line, geographic region, prior stroke, cardiac arrhythmias, congestive heart failure, chronic pulmonary disease, uncomplicated diabetes, complicated diabetes, hypertension, fluid and electrolyte disorders, valvular disease, peripheral vascular disorders, hypothyroidism, solid tumor without metastasis, deficiency anemias, depression, dementia, concurrent cardiac events, mechanical ventilation, gastrostomy tube, hemiplegia/hemiparesis, residual neurological deficit, year of index hospitalization, and HMO membership.

Table 3. Hazard ratios (HR) and 95% confidence intervals (CI) for the relationship between neurology care and 30-day cause-specific rehospitalization (n = 44,099)

Clinical Classification System (CCS) ^a	CCS Level	Frequency (n = 44,099)	Neurologist only vs. generalist only		Collaborative care vs. generalist only		Other specialist vs. generalist only		No physician claims vs. generalist only	
			HR ^b	95% CI	HR ^b	95% CI	HR ^b	95% CI	HR ^b	95% CI
Not rehospitalized	n.a.	24,113	1.00		1.00		1.00		1.00	
Infections and aspiration pneumonia	1, 8.1, 9.1, 10.4.1, 12.1, 13.1	3,733	0.88	0.78, 0.999	1.00	0.91, 1.09	0.94	0.78, 1.12	1.00	0.75, 1.34
Heart disease	7.2	3,250	1.17	1.02, 1.34	1.08	0.97, 1.20	1.08	0.90, 1.31	0.97	0.57, 1.65
Acute cerebrovascular disease	7.3.1	1,849	0.98	0.84, 1.14	0.98	0.85, 1.13	1.18	0.90, 1.54	1.21	0.81, 1.80
Non-acute cerebrovascular disease	7.3.2, 7.3.3, 7.3.4, 7.3.6	1,397	0.99	0.79, 1.23	1.19	1.003, 1.4	1.00	0.72, 1.39	1.27	0.71, 2.28
Respiratory disease other than infection/aspiration and circulatory disease other than heart	7.1, 7.4, 7.5, 8.2, 8.3, 8.5, 8.6, 8.8, 8.9	1,611	1.02	0.84, 1.24	1.12	0.97, 1.31	1.13	0.84, 1.51	0.79	0.43, 1.46
Symptoms, signs, and ill-defined conditions	17	847	0.92	0.71, 1.19	0.96	0.77, 1.19	1.00	0.68, 1.46	3.85	1.07, 13.89
Injury and poisoning	16	1,405	0.95	0.78, 1.16	1.03	0.88, 1.20	0.85	0.60, 1.21	0.80	0.42, 1.54
Other	remaining codes	5,894	1.08	0.99, 1.18	1.00	0.93, 1.07	1.04	0.91, 1.19	1.09	0.84, 1.43

^a Category indicates primary diagnosis for first rehospitalization within 30 days of the index admission.

^b Adjusted for age, female, race, Medicaid, % of the census block group aged ≥ 25 years with college degrees, % of persons in the census block group below the poverty line, geographic region, prior stroke, cardiac arrhythmias, congestive heart failure, chronic pulmonary disease, uncomplicated diabetes, complicated

diabetes, hypertension, fluid and electrolyte disorders, valvular disease, peripheral vascular disorders, hypothyroidism, solid tumor without metastasis, deficiency anemias, depression, dementia, concurrent cardiac events, mechanical ventilation, gastrostomy tube, hemiplegia/hemiparesis, residual neurological deficit, year of index hospitalization, and HMO membership.

Table 4. Adjusted predicted means or probabilities and 95% confidence intervals (CI) for discharge destination, length of stay, and warfarin use within 30 days, by neurology care category (n = 44,099)

Variable	Generalist only (n = 8,071)		Neurologist only (n = 7,408)		Collaborative care (n = 26,558)		Other specialist (n = 1,607)	
	percent or mean ^a	95% CI	percent or mean ^a	95% CI	percent or mean ^a	95% CI	percent or mean ^a	95% CI
Length of stay, mean in days	5.2	5.1, 5.3	5.6	5.5, 5.7	6.1	6, 6.1	4.6	4.4, 4.7
Discharge destination, %								
Home	29	28, 30	30	29, 31	26	26, 27	31	29, 34
Home care	14	13, 15	14	13, 15	14	14, 14	13	11, 15
Rehabilitation facility	12	11, 13	19	18, 20	19	19, 20	13	11, 15
Skilled nursing facility	32	31, 33	26	25, 27	31	30, 31	27	25, 29
Other ^b	12	11, 13	11	10, 11	10	10, 11	15	14, 17
Warfarin use, % ^c	17	16, 18	19	18, 20	18	18, 19	17	14, 19

^a Adjusted for age, female, race, Medicaid, % of the census block group aged ≥ 25 years with college degrees, % of persons in the census block group below the poverty line, geographic region, prior stroke, cardiac arrhythmias, congestive heart failure, chronic pulmonary disease, uncomplicated diabetes, complicated diabetes, hypertension, fluid and electrolyte disorders, valvular disease, peripheral vascular disorders, hypothyroidism, solid tumor without metastasis, deficiency anemias, depression, dementia, concurrent

cardiac events, mechanical ventilation, gastrostomy tube, hemiplegia/hemiparesis, residual neurological deficit, year of index hospitalization and HMO membership.

^b 'Other' includes 3,183 patients who died during the index hospitalization, 1,209 patients discharged to hospice, 181 patients discharged to other facilities, and 199 patients with length of stay ≥ 30 days (65 patients met more than 1 criterion).

^c Excludes 'Other' defined above.

Discussion

This study corroborates previous studies [1, 2] that found care by a neurologist is associated with better outcomes but also found no evidence that collaborative care by a generalist and neurologist is associated with better outcomes than care by a neurologist alone. This contrasts with studies showing improved care for patients with myocardial infarction [13] and congestive heart failure [14] when treated collaboratively compared with care by either cardiologists or generalists alone. Because patients who saw a neurologist alone had more severe stroke but fewer comorbidities, it is possible that our finding is related to unidentified factors (e.g., unmeasured comorbidities) that we could not control for in this study. However, patients who received collaborative care had both more severe stroke and similar comorbidities when compared to patients who received generalist care only, yet still showed decreased mortality. It is also possible that other unmeasured differences between patients might also explain our results through residual confounding.

Our results represent the first population-based evidence indicating that care by a neurologist is associated with lower risk of rehospitalizations for infections and aspiration. This is consistent with a large meta-analysis

suggesting that stroke units may lower the risk of 'complications of immobility' that could lead to death (examples included sepsis, venous thromboembolism, and decubitus ulceration), although the authors viewed their analyses as only suggestive [7]. However, it is important to note that stroke units are based on a collaborative care model characterized by collaborative multidisciplinary team care. Only a minority of these trials incorporated formal neurological department care. Results are also consistent with the hypotheses that neurologists improve outcomes specifically by reducing the potential for aspiration (through increased swallowing evaluations) or by improving functioning (through use of rehabilitation therapy) [3]. In contrast to previous work [7], we found no evidence that neurology care was associated with lower risk of cardiovascular complications and, in fact, our data suggested the opposite association.

There are a variety of complex factors that may explain these differences in outcomes. Different practice styles by neurologists when compared to generalists may be particularly relevant [1, 3]. Important aspects of neurologist practice style include increased use of interventions by other specialties (occupational and speech therapy) [3] and use of other facilities (inpatient rehabilitation facilities [1]). Through increased referrals to these other spe-

cialties and facilities, neurologists represent an initial contact that may have complex effects on subsequent outcomes. This may be supported by our results suggesting that discharge destination partially explained the association between infections and aspiration pneumonitis. However, we did not have data on occupational and speech therapy, or on swallowing evaluations, which may also contribute to explaining these results.

Administrative data provide large sample sizes to study cause-specific rehospitalizations, but such data also have substantial limitations. By using the primary discharge diagnosis code, we improve the likelihood of identifying true stroke but may bias the sample toward more benign outcomes as non-primary position patients have a larger comorbidity burden and higher 30-day case fatality [15]. This approach may have led us to underestimate outcomes compared to the entire population of stroke patients.

Given the substantial burden associated with caring for older stroke patients in the United States, future studies should continue to examine the mechanisms by which neurologists working alone or collaboratively may achieve better outcomes for stroke care. If additional studies support our findings, the specific processes of care that lead to these improved outcomes need to be identified. Improved understanding of how neurologists might translate care processes into better outcomes can support both increased use of neurologists in caring for stroke and education for generalists about specific processes of stroke care that may improve outcome.

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References

- Mitchell JB, Ballard DJ, Whisnant JP, Ammering CJ, Samsa GP, Matchar DB: What role do neurologists play in determining the costs and outcomes of stroke patients? *Stroke* 1996; 27:1937–1943.
- Smith MA, Shahar E, McGovern PG, Kane RL, Doliszny KM, Arnett DK, Luepker RV: HMO membership and patient age and the use of specialty care for hospitalized patients with acute stroke: the Minnesota Stroke Survey. *Med Care* 1999;37:1186–1198.
- Goldstein LB, Matchar DB, Hoff-Lindquist J, Samsa GP, Horner RD: VA Stroke Study: neurologist care is associated with increased testing but improved outcomes. *Neurology* 2003; 61:792–796.
- Kaste M, Palomaki H, Sarna S: Where and how should elderly stroke patients be treated? A randomized trial. *Stroke* 1995;26:249–253.
- Lees KR: Stroke is best managed by a neurologist: battle of the titans. *Stroke* 2003;34:2764–2765.
- Caplan L: Stroke is best managed by neurologists. *Stroke* 2003;34:2763.
- Stroke Unit Trialists' Collaboration: How do stroke units improve patient outcomes? A collaborative systematic review of the randomized trials. *Stroke* 1997;28:2139–2144.
- Diez-Tejedor E, Fuentes B: Acute care in stroke: do stroke units make the difference? *Cerebrovasc Dis* 2001;11(suppl 1):31–39.
- Clinical Classifications Software (ICD-9-CM): Summary and Downloading Information. Rockville, Agency for Healthcare Research and Quality, 2003.
- Elixhauser A, Steiner C, Harris DR, Coffey RM: Comorbidity measures for use with administrative data. *Med Care* 1998;36:8–27.
- Horner RD, Sloane RJ, Kahn KL: Is use of mechanical ventilation a reasonable proxy indicator for coma among Medicare patients hospitalized for acute stroke? *Health Serv Res* 1998;32:841–859.
- Quan H, Parsons GA, Ghali WA: Validity of procedure codes in International Classification of Diseases, 9th revision, clinical modification administrative data. *Med Care* 2004;42:801–809.
- Ayanian JZ, Guadagnoli E, McNeil BJ, Cleary PD: Treatment and outcomes of acute myocardial infarction among patients of cardiologists and generalist physicians. *Arch Intern Med* 1997;157:2570–2576.
- Chin MH, Wang JC, Zhang JX, Sachs GA, Lang RM: Differences among geriatricians, general internists, and cardiologists in the care of patients with heart failure: a cautionary tale of quality assessment. *J Am Geriatr Soc* 1998; 46:1349–1354.
- Tirschwell DL, Longstreth WT Jr: Validating administrative data in stroke research. *Stroke* 2002;33:2465–2470.