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Influence of Physician Specialty on Outcomes after Acute Ischemic Stroke

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Abstract

Background—Specialist care is shown to improve outcomes for several complex medical conditions. For ischemic stroke, prior studies suggest that admission to neurologists is associated with better outcomes, but these may incompletely control for confounding prognostic differences.

Objective—To evaluate whether admission to a neurologist is associated with improvement in outcomes of stroke patients after controlling for initial prognostic differences.

Design—Retrospective cohort study.

Setting—113 U.S. academic hospitals.

Patients—Demographic and clinical data for all ischemic stroke patients admitted through emergency departments in 1997–1999 from an administrative database.

Measurements—In traditional analyses, we evaluated attending physician specialty as a predictor of in-hospital mortality. In grouped-treatment (GT) analyses, a method based on the instrumental variable approach that bypasses selection bias, the hospital rate of stroke admission to neurologists was used as the predictor. We used generalized estimating equations for all analyses, adjusting for demographics, urgency, co-morbid illness severity, and treatment volume.

Results—Of 26,925 ischemic stroke patients, 60% were admitted to neurologists. In univariate analysis, risk of in-hospital mortality in cases admitted to neurologists (4.6%) was lower than for generalists (9.5%; $p<0.001$). Adjustment for individual level characteristics did not alter the association (0.60 OR, 95% CI, 0.50–0.72; $p<0.001$). However, no advantage to neurologist admission was demonstrated in GT analysis, with mortality rates similar at hospitals admitting different proportions of ischemic stroke cases to neurologists (1.02 OR, 95% CI, 0.79–1.30; $p=0.90$).

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Conclusions—Differences in ischemic stroke outcomes between neurologists and generalists may be due to differences in initial prognosis since outcomes are no better at hospitals that admit to neurologists more frequently.

Keywords

ischemic stroke; outcomes measurement; quality improvement

Introduction

The appropriate role of specialists in the hospital management of common medical conditions has been vigorously debated.[1–3] Few argue that specialists serve an important role as consultants, but whether patients with specific conditions should be admitted to specialists or generalists is unresolved. This is demonstrated in the large degree of hospital-to-hospital variability in the proportion of patients with myocardial infarction admitted to cardiologists,[4] asthma exacerbations to pulmonologists,[5] and renal failure to nephrologists.[6]

Stroke is another common diagnosis with variable rates of admission to specialists and generalists. Several prior studies have suggested that outcomes after ischemic stroke are better if a neurologist is the attending physician.[7–10] However, these observational studies cannot rule out the possibility that differences in outcome are due to prognosis at the time of admission rather than to improvements in medical care. While these studies have controlled for known prognostic variables, it is possible that unknown, unmeasured, or inadequately measured variables are different in the groups admitted to neurologists and to generalists. These differences, in turn, may account for outcome differences rather than specialist care.

This form of selection bias, a type of confounding by indication, is a constant threat to validity in observational studies. Randomized trials avoid it because the randomization process balances all prognostic variables, both known and unknown, in the treatment groups.[11] Observational studies cannot guarantee the same balance of unmeasured risk factors.[12] Multivariate modeling is meant to account for prognostic differences between groups in observational studies, but confounding by indication may remain if all the factors that determine prognosis are not accurately measured. We developed a method to avoid confounding by indication by evaluating individual outcome differences associated with practice variability.[13] The technique, termed grouped-treatment (GT) analysis, is related to the instrumental variable approach developed by economists and occasionally applied to health services research.[14]

In multivariate GT analyses, the institutional proportion of cases admitted to a neurologist is used as a predictor of outcomes rather than whether an individual patient was admitted to neurology. For example, at a hospital where three-quarters of acute stroke patients are admitted to neurology, all patients are treated as having a 75% chance of admission to neurology. Rather than denoting whether each patient's attending specialty was a neurologist or generalist, the 0.75 probability of admission to neurology is used for analysis. If admission to an attending neurologist improves ischemic stroke care, then GT analysis should demonstrate that hospitals admitting higher proportions of stroke patients to neurologists have improved outcomes regardless of whether selection bias is present at the individual patient level. In this way, the method bypasses unmeasured confounders at the individual level in its estimates of treatment effects. The method is susceptible to confounding at the group level; that is, unmeasured prognostic differences in patients admitted to hospitals that rely more heavily on neurologists could bias the GT estimate of treatment effect. The GT estimates are accurate if it can be assumed that hospitals' rates of treatment are not associated (in an unmeasured way) with their patient population's intrinsic, pre-treatment prognosis. However, practice variability is very common between hospitals and is generally poorly associated with systematic differences in prognosis of the treated patients,[15, 16] and in this setting GT provides an independent assessment of treatment effect that may either confirm or refute an association found at the individual level, where confounding is nearly always an important issue.

In this study, we evaluated the impact of admission to a neurologist or generalist on outcomes of ischemic stroke patients treated at academic medical centers throughout the United States. We also compared traditional analysis to GT analysis. In doing so, we demonstrate the influence of unmeasured confounders on observational assessments of specialist care and may provide a more accurate measure of the impact of care by a neurologist on outcomes after ischemic stroke.

Methods

We used the University HealthSystem Consortium (UHC) administrative database, which contained patient information from 84 large academic health centers and their 39 associate hospitals, with over 2.1 million discharges each year.[17] We obtained UHC discharge abstracts for all ischemic stroke patients admitted through emergency departments from 1997 through 1999. Discharge abstracts included patient demographics, urgency status (emergent, urgent, elective), illness severity class, admitting and discharge specialties, discharge diagnoses, procedure codes, in-hospital mortality, length-of-stay, and total hospital charges. Patients were identified using *International Classification of Diseases, Ninth Revision* (ICD-9) codes that were previously recognized as specific indicators of acute ischemic stroke (ICD-9 433.01, 433.11, 433.21, 433.31, 433.81, 433.91, 434.01, 434.11, 434.91, 436).[18–20] We limited the cohort to emergency-department admissions to reduce the likelihood of referral bias.

Variables in the discharge database were validated by comparison with a detailed medical record review. Between June and December 1999, 42 institutions participating in a quality improvement project identified 30 consecutive ischemic stroke cases. Trained analysts or clinicians abstracted information on demographics, medical history, and treatment. Kappa statistics have been previously reported for all individual characteristics, except hospital charges, for which medical record review data were not available.[21] Demographic and clinical variables in the administrative database tended to agree well with medical record review, with agreement ranging from 85–100% (kappas 0.58–1.00). Since the admitting attending likely directed acute stroke management, this was used to define a patient's attending physician specialty in all analyses. Administrative coding of tPA use was imperfect with a sensitivity of 50%, but a specificity of 100%.[22]

Institutional rate of admission to neurologists versus generalists was calculated as the percentage over the entire study duration. The distribution of patient pre-treatment prognostic factors was compared between institutions above and below the 50th percentile for rate of admission to neurology with unadjusted logistic regression because generalized estimating equations that could account for clustering were unable to support these models due to diverging estimates. We calculated the yearly volume of ischemic strokes treated at an institution from discharge abstracts, including admissions from all sources since all treated cases would be expected to increase physician experience.

In-hospital mortality was chosen as the primary outcome due to its frequency, importance, and coding reliability. Univariate predictors of in-hospital mortality were identified using Pearson's chi-squared and Wilcoxon rank-sum tests.[23] Length-of-stay (LOS), total hospital charges, and receipt of tPA were secondary outcomes. LOS and total hospital charges were compared using the Wilcoxon rank-sum test. LOS and total charge calculations included only those patients surviving to discharge so that early mortality would not be confused with more efficient care. Similarly, we compared demographics and clinical variables between patients admitted to neurologists and generalists. To evaluate variability between institutions, we determined the proportion of patients with specific characteristics and outcomes at each institution and report median values and the 10^{th}- to 90^{th}-percentile range among the institutions. The correlation between the institutional rate of admission and the institutional rate of mortality was evaluated.

In standard multivariate analysis, we assessed physician specialty as a predictor of individual patients' in-hospital mortality after adjustment for demographic characteristics, admission status (emergent, urgent, elective), co-morbid illness severity score (range 0–4; 0 is no substantial co-morbid illness, 4 is catastrophic co-morbid illness), and annual institutional treatment volume of ischemic stroke. UHC defined severity class to represent an individual's overall calculated risk of illness; its value was dependent on the refinement of the Health Care Facility Administration's diagnosis-related groups (DRGs) and the Sach's Complication Profiler count of total comorbidities present.[24, 25] Effects on LOS and total charges, as well as the ability of physician specialty to predict tPA use in individual patients, were similarly evaluated. Analyses of tPA use were restricted to patients admitted to universities that ever coded tPA use, which increases the sensitivity of the indicator to 57%.[22] Residual misclassification error of tPA use would be expected to obscure a true underlying association between its use and physician specialty.

In multivariate GT calculations, we used the institutional proportion of cases admitted to a neurologist as a predictor of outcomes. GT analysis is based on the observation that if a treatment is effective, hospitals that use it more frequently should have better patient outcomes and that this association should persist regardless of whether individual-level selection bias is present. The method assumes that hospital rates of admission to neurology are independent of the patient population's pre-treatment prognosis. Since utilization differences between hospitals likely reflect practice variability rather than differences in patient prognosis,[15, 16] the influence of unmeasured confounders at the hospital level is expected to be small. Measured variables that proved significant in univariate analyses or thought to be responsible for an association between overall patient prognosis and modalities and frequencies of acute stroke treatments used, such as institutional treatment volume, were included in the multivariate GT model in order to isolate the effect of increasing rates of admission to neurologists.

We included both institutional and individual data to more accurately specify individual outcomes and covariates compared to an analysis that simply compared institutions' characteristics and their outcomes.[26] Generalized estimating equations (GEE) were used in order to account for institutional clustering of predictor variables and outcomes. GEE is similar to logistic regression, but produces broader confidence intervals (CI) because logistic regression ignores the possibility that individuals at institutions are more similar to each other than would be expected by chance alone. We used a compound symmetry correlation structure, which initiates modeling by assuming a constant correlation between observations within each institution as well as between institutions, and used a logistic link function for binary outcomes in order to mimic logistic regression. The natural log transformations of LOS and hospital charges were modeled to reduce positive skew and approximate a normal distribution, and an identity link function was used in GEE to mimic linear regression for these analyses. To evaluate the impact of adjustment, both unadjusted and adjusted analyses were conducted. Methods to calculate power of GT analysis are not available. The Stata statistical package was used for all analyses (Version 8.0, Stata Corporation, College Station, TX).

Results

A total of 26,925 patients with ischemic strokes were admitted to neurologists or generalists through the emergency department at 113 institutions participating in the study. Patients admitted to neurologists rather than generalists (Table 1) were more often younger, more likely to be male, but less likely to have serious co-morbid illness. Institutions varied widely in the demographics of treated patients as well as markers of pre-treatment prognosis. Institutional annual case volume of all ischemic strokes ranged from 1 to 741. Mortality rates, mean LOS, and mean hospital charges also varied broadly between institutions (Table 1). Patients treated at institutions in the upper 50th percentile admission rate to neurologists were younger and more often male, but did not differ in illness severity class (Table 2).

In-hospital deaths occurred in 1760 cases (7.0%). In univariate analysis, older age ($p<0.001$), white ethnicity ($p<0.001$), emergent stroke ($p<0.001$), and increased illness severity ($p<0.001$) were associated with greater risk of death, while African-American ($p<0.001$) and Hispanic ($p=0.007$) ethnicities were protective. No other patient characteristics were important, and institutional annual case volume showed no association to mortality risk.

Overall, 60% of patients with ischemic stroke were admitted to a neurologist's care. In univariate analysis (Table 3), a lower risk of in-hospital mortality was observed in cases admitted to neurologists (4.6%) compared to generalists (9.5%; $p<0.001$). After adjustment in standard multivariable models, the association between neurologist admission and lower risk of death persisted (OR 0.60; 95% CI, 0.50–0.72; $p<0.001$).

The institutional rate of admission of ischemic stroke patients to neurologists ranged from 0% to 90%, and higher rates were seen at hospitals with higher institutional case volumes ($p<0.001$). There was no correlation between the institutional rate of admission to neurology and the institutional mortality rate (0.33; $p=0.73$). At the individual-level, greater rates of admission to neurologists had no significant impact on mortality (OR 1.05; 95% CI, 0.85–1.31; $p=0.64$; Table 3) in unadjusted analysis. After adjustment for patient demographics, co-morbid illness severity score, urgency status, and institutional case volume in GT analysis, there remained no association between death and proportion of ischemic stroke cases admitted to neurologists (OR 1.02; 95% CI, 0.79–1.30; $p=0.90$), consistent with the absence of an association between neurologist care and in-hospital mortality.

Patients treated by neurologists were likely to have shorter stays ($p<0.001$) and lower charges ($p=0.01$) in univariate analysis (Table 4). In traditional adjusted multivariable analysis, the same associations were seen for LOS ($p<0.001$) and charges ($p=0.05$). However, in adjusted GT analyses, increased institutional rates of admission to neurologists were not associated with briefer LOS ($p=0.36$), and were associated with greater hospital charges ($p=0.044$).

In 1999, 190 (2.2%) ischemic stroke patients received tPA at the 64 universities that had ever coded tPA use. In univariate analysis, patients admitted to a neurologist were more likely to have received tPA ($p=0.001$; Table 3), and this association persisted after adjustment ($p<0.001$). In adjusted GT analysis, institutions admitting a higher proportion of ischemic stroke patients to neurologists also treated patients with tPA more frequently ($p=0.033$).

Discussion

Several prior studies found that ischemic stroke outcomes were better when an attending neurologist was responsible for patient care.[7–10] Traditional analyses of our data also indicate that care by a neurologist lowers inpatient mortality, LOS, and total charges. By contrast, a GT analysis that bypasses selection bias at the patient level suggests there is no independent benefit of neurologist care on mortality or LOS and actually shows higher associated charges.

The discrepancy between standard and GT analyses suggests that healthier patients may have been preferentially admitted to neurologists. Measured pre-treatment prognostic factors in our data present a mixed picture: patients admitted neurologists were younger, more often male, more often emergently admitted, and less likely to have serious co-morbid illnesses. These patient factors were controlled for in all adjusted analyses. While traditional multivariate analysis attempts to adjust for variations between the two patient populations, it cannot adjust for inaccurately measured or unmeasured differences. Using the institutional proportion of admissions to neurologists as a predictor of patient outcomes, we were better able to control for the selection bias associated with differential distribution of patients to teams led by attending neurologists versus generalists.[13, 14]

Petty *et al*[7] studied 299 ischemic stroke patients and showed equivalent survival among stroke patients admitted to neurology inpatient teams versus generalist teams with neurologic consultation. However, patients cared for by generalist teams without neurologic consultation fared worse. Their subjects were treated at both academic and community hospitals. In our study, contributing hospitals were solely academic institutions. Since specialty cross-talk may be more frequent at university-based hospitals, academic-based generalist physicians may be more familiar with recent stroke literature and guidelines than their community-based peers. Further, restricting analysis to academic centers in our study should reduce potential confounding influences of differences between other aspects of institutional care. While no information was available on neurologist consultation in our database, informal consultation is expected to play a large hidden role at academic medical centers. Thus, the inclusion of a formal consultation variable may be misleading at academic medical centers.

Analyzing claims data on 44,099 Medicare beneficiaries with acute ischemic strokes cared for at both academic and community hospitals, Smith *et al*[10] also recently reported a 10% lower risk of 30-day mortality and 12% lower risk of re-hospitalization for infections and aspiration pneumonitis among patients admitted to neurologists compared to generalists. However, the upper 95% confidence interval limits for these two findings nearly crossed 1 (ranging from 0.998–0.999). The study also concluded that patients cared for collaboratively by generalists and neurologists had a 16% lower 30-day mortality risk (hazard ratio 0.84; 95% CI, 0.79–0.90) than by generalists alone, but simultaneously noted that patients admitted to generalists only had more comorbidities than either the collaborative care or neurologist only patient groups. If sicker patients were triaged to generalist admission, as occurs in confounding by indication (also known as channeling bias), then incomplete adjustment for comorbid disease may bias outcomes in favor of neurologist involvement. The GT analysis we employed is specifically designed to overcome this exact type of selection bias.

In our study, patients admitted to neurologists received tPA significantly more often than those admitted to generalists. GT analysis also found that hospitals admitting a higher proportion of strokes to neurologists treated more patients with tPA. This result is consistent with a prior study demonstrating that academic institutions employing a vascular neurologist had significantly higher odds of administering tPA.[21] Since tPA must be administered within 3 hours of symptom onset,[27] it is commonly delivered in the emergency department prior to admission. Thus, patients may be preferentially selected for admission to neurologic services because of their receipt of tPA, rather than this association reflecting an actual increased use of tPA by neurologists over generalists. Alternatively, institutions with higher rates of stroke admissions to neurology may be simply more familiar with tPA protocols. Importantly, the poor sensitivity of our data for actual tPA administration may affect the analysis of its use by physician specialty; however, the failure to administratively code tPA use is unlikely to be differentially biased based on physician specialty. Thus, undercoding of tPA use would be expected to bias these analyses toward the null.

The potential advantage and efficacy of stroke centers, stroke units, stroke services, or other institutional processes of care is not addressed by our data. Previously, we found that acute ischemic stroke mortality was lower at hospitals employing a vascular neurologist and at those with guidelines stating only neurologists could administer tPA at academic hospitals.[21] A later analysis evaluated the impact of all elements of stroke center care supported by the original Brain Attack Coalition consensus,[28] and found that no single element improved mortality.[29] However, recent studies find significant mortality benefit associated with stroke units[30, 31] and stroke services.[32] Clearly, the debate continues over these important questions.

Our study has several limitations. First, generalizeability may be lessened because only academic medical centers contributed data and only admissions through the ED were included. However, limiting the study population to academic centers provided a homogenous study population and greatly reduced the potential for confounding at the institutional level. While the selection of ED cases mitigated the effects of referral bias and the use of only academic hospitals minimized inter-institutional differences, institutions above and below the 50th percentile rate of admissions to neurology did differ. However, this difference did not consistently result in patients with worse pre-treatment prognostic factors being cared for at hospitals with higher rates of admission to neurology. Second, administrative data have important limitations. In our study, patients were selected based on diagnostic coding of records analysts at discharge, and the diagnostic accuracy of such coding for stroke is imperfect.[33] Furthermore, missing or incomplete information could have impaired adjustments for patient differences. Third, details of patient treatment were limited. The lack of information about formal and informal consultations may have obscured a true difference in outcomes among specialties.[7] Additionally, academic institutions may more often utilize systematized care plans than community hospitals, potentially minimizing differences between specialties. Fourth, at the time of our study, tPA had been recently introduced into stroke care. Current rates of tPA use among neurologists and generalists may be more similar. Fifth, the ability of in-hospital mortality to adequately assess quality of care is limited and longer-term and functional outcomes would be better measures and more clinically relevant.

After controlling for selection bias using GT analysis, we found stroke outcomes to be similar regardless of whether a neurologist or generalists was the admitting physician. This result contrasts with the findings of several previous studies that suggested admitting stroke patients to a neurologist resulted in better clinical outcomes.[7–10] Since only one neurologist is employed for approximately every 19.8 generalists in the United States (US)[34] and 40% of acute strokes were cared for by generalists even in this sample entirely restricted to university hospitals, such findings would insinuate that many US stroke patients receive inferior care. Because the role of neurologist as consultant, rather than attending physician, is significantly more feasible in the majority of practice settings, the demonstration of equivalent outcomes by both types of physicians is reassuring and certainly reinforces the important role that unmeasured confounders may play in observational studies.

However, these results do imply that it is vital that generalists remain fully trained in the current best practices of acute stroke management to maintain an equivalence of care suggested here. Given the sheer commonness of acute stroke, any proposed future hospitalist training, certification, and re-certification programs should include a focus on acute stroke management.

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TABLE 1

Individual and Institutional Characteristics of Ischemic Stroke Patients by Attending Specialty

Characteristic	Neurologist (n=16,287)	Generalist (n=10,638)	Institutional (n=113) Median	Institutional (n=113) (10^{th} – 90^{th} percentile)
Age (years, mean (SD))	66.2 (14.7)	69.3 (15.2)	67.7	(62.1–74.8)
Female, no. (%)	8291 (51)	5904 (56)	54%	(46–67%)
Ethnicity				
African-American, no. (%)	4516 (28)	3335 (31)	19%	(0–71%)
Asian-American, no. (%)	570 (4)	201 (2)	0.7%	(0–8%)
Hispanic, no. (%)	906 (6)	458 (4)	0.7%	(0–16%)
Native American, Eskimo, no. (%)	48 (0)	21 (0)	0%	(0–1%)
White, no. (%)	9012 (55)	5851 (55)	65%	(10–95%)
Other ethnicity, no. (%)	398 (2)	157 (1)	0.3%	(0–4%)
Unknown, no. (%)	837 (5)	615 (6)	0.1%	(0–9%)
Co-morbid illness severity score*, median (inter-quartile range)	1 (0–1)	1 (0–1)	0.83	(0.65–0.95)
Treatment and Outcome				
tPA administered, no. (%)†	132 (3)	51 (2)	1.9%	(0.6–6.5%)
In-hospital deaths, no. (%)	755 (5)	1005 (9)	6.1%	(3–10%)
Discharges to home, no. (%)	9504 (59)	5235 (49)	52%	(38–72%)
Length of Stay (days, mean (SD))	6.6 (7.2)	7.9 (9.9)	6.6	(4.2–10.0)
Total Charges	$16,600 ($20,500)	$18,700 ($26,300)	$15,000	($9000–$30,000)

*Co-morbid illness severity score range is 0 to 4. Zero represents no substantial co-morbid illness; 4 is catastrophic co-morbid illness.

†Based on 52 institutions ever coding tPA use for ischemic stroke in 1999. Neurologists, n=4857; generalists, n=3351.

TABLE 2

Patient Pre-treatment Prognostic Factors Between Institutions with Rates of Admission to Neurologists Above and Below the 50th Percentile

Characteristic	< 50th percentile	>50th percentile	P-value
Age (years, mean (SD))	66.7 (15.2)	69.4 (14.3)	<0.001
Female, no. (%)	5288 (54)	8907 (52)	0.001
Co-morbid illness severity score*, median (inter-quartile range)	1 (0–1)	1 (0–1)	0.87

*Co-morbid illness severity score range is 0 to 4. Zero represents no substantial co-morbid illness; 4 is catastrophic co-morbid illness.

TABLE 3

Physician Specialty, In-Hospital Mortality, and tPA Use in Ischemic Stroke (n=26,925)*

	Unadjusted		Adjusted†	
Characteristics	**Odds Ratio (95% CI)**	***P* value**	**Odds Ratio (95% CI)**	***P* value**
Mortality				
Attending neurologist	0.32 (0.26–0.39)	<.001	0.60 (0.50–0.72)	<.001
Proportion of admissions to neurology	1.05 (0.85–1.31)	0.64	1.02 (0.79–1.30)	0.90
tPA Use†				
Attending neurologist	1.87 (1.30–2.69)	0.001	2.56 (1.72–3.78)	<.001
Proportion of admissions to neurology	2.32 (0.98–5.49)	0.06	2.47 (1.08–5.65)	0.03

Abbreviations: tPA, tissue plasminogen activator.

*Analysis limited to 1999 and to 52 institutions ever coding tPA use for ischemic stroke in 1999 (n=8208).

†Analyses adjusted for age, gender, ethnicity, urgency status, illness severity class, and institutional annual acute stroke case volume.

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TABLE 4

Physician Specialty and Secondary Outcomes of Ischemic Stroke

	Unadjusted Analysis			Adjusted Ratio*	
Characteristic	**Neurologist**	**Generalist**	***P* value**	**Ratio (95% CI)**	***P* value**
LOS (days), n=25,094					
Standard Analysis	6.6	8.0	<0.001	0.92 (0.88–0.96)	<0.001
Group-treatment analysis	7.2	7.1	0.80	1.06 (0.94–1.19)	0.35
Total Charges, n=21,812					
Standard Analysis	$16,600	$18,700	0.01	0.95 (0.91–1.00)	0.05
Group-treatment analysis	$17,800	$16,900	<0.001	1.26 (1.01–1.57)	0.04

*Analyses adjusted for age, gender, ethnicity, urgency status, illness severity class, and institutional annual acute stroke case volume.