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Pre-Existing Mild Cognitive Impairment, Dementia, and Receipt of Treatments for Acute Ischemic Stroke

Deborah A. Levine, MD, MPH, **Andrzej T. Galecki, MD, PhD**, **Lewis B. Morgenstern, MD**, **Darin B. Zahuranec, MD, MS**, **Kenneth M. Langa, MD, PhD**, **Mohammed U. Kabeto, MS**, **Dolorence Okullo, MHI**, **Brahmajee K. Nallamothu, MD, MPH**, **Bruno Giordani, PhD**, **Bailey K. Reale, MPH**, **Morgan Campbell, MD**, **Lynda D. Lisabeth, PhD**

Department of Internal Medicine and Cognitive Health Services Research Program (DAL, ATG, KML, MUK, DO, BKN, BKR), Department of Neurology and Stroke Program (DAL, LBM, DBZ, LLD), Institute for Healthcare Policy and Innovation (DAL, LBM, KML, BKN), Department of Biostatistics (ATG), Department of Psychiatry & Michigan Alzheimer's Disease Center (BG), Department of Epidemiology (LBM, LDL), University of Michigan, Ann Arbor, MI; VA Ann Arbor Healthcare System (KML, BKN), MI; Neuroscience Institute and Stroke Program Medical Director (MC), Christus Spohn Shoreline, Corpus Christi, TX

Abstract

Background and Purpose: Differences in acute ischemic stroke (AIS) treatment by cognitive status are unclear but some studies have found patients with pre-existing dementia get less treatment. We compared AIS care by pre-existing cognitive status.

Methods: Cross-sectional analysis of prospectively-obtained data on 836 adults ≥45 with AIS from the population-based Brain Attack Surveillance in Corpus Christi project from 2008–2013. We compared receipt of a composite quality measure representing the percentage of seven treatments/procedures received (ordinal scale; values, <0.75, 0.75–0.99, and 1.0), a binary defect-free quality score, and individual treatments after AIS between patients with pre-existing dementia (Informant Questionnaire on Cognitive Decline in the Elderly score ≥3.44), mild cognitive impairment (MCI, score 3.1–3.43) and normal cognition (score ≤3).

Results: Among patients with AIS, 42% had normal cognition (47% women; median age [IQR], 65 [56–76]), 32% had MCI (54% women; median age, 70 [60–78]), 26% had dementia (56% women; median age, 78 [64–85]). After AIS, 44% of patients with pre-existing dementia and 55% of patients with pre-existing MCI or normal cognition received defect-free care. Compared to cognitively normal patients, patients with pre-existing MCI had similar cumulative odds (unadjusted cumulative odds ratio, ucOR=0.99, P=0.92) and patients with pre-existing dementia

Corresponding Author: Deborah A. Levine, MD, MPH, U-M Division of General Medicine, NCRC 16-430W, 2800 Plymouth Road, Ann Arbor, MI 48109-2800, Telephone: 734-936-5216, deblevin@umich.edu.

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Supplemental Materials:
Online Figure 1
Expanded Methods
Online Tables 1–6

had 36% lower cumulative odds of receiving the composite quality measure (ucOR=0.64, P=0.005). However, the dementia-quality association became non-significant after adjusting for patient factors, namely sex, comorbidity, and BMI (adjusted cOR [acOR]=0.79, P=0.19). Independent of patient factors, pre-existing MCI was negatively associated with receipt of intravenous t-PA (acOR=0.36, P=0.04), rehabilitation assessment (acOR=0.28, P=0.016), and echocardiogram (acOR=0.48, P<0.001). Pre-existing dementia was negatively associated with receipt of anti-thrombotic by day 2 (acOR= 0.39, P=0.04) and echocardiogram (acOR=0.42, P<0.001).

Conclusion: Patients with pre-existing MCI and dementia, compared to cognitively normal patients, may receive less frequently some treatments and procedures, but not the composite quality measure, after AIS.

Keywords

stroke; mild cognitive impairment; dementia; quality of health care

AHA Journals Subject Terms:

Cerebrovascular Disease/Stroke; Cognitive Impairment; Quality and Outcomes; Health Services

Introduction

Up to 1 in 5 older adults (65+) have mild cognitive impairment (MCI), and another 1 in 7 have dementia.[1,2] The numbers of older Americans diagnosed with MCI and dementia are projected to triple by 2050[3] because of population aging, improved survival from cardiovascular disease (CVD) and cancer, and increased screening for cognitive impairment as mandated by the Affordable Care Act.[4] Although both MCI and dementia are characterized by measurable cognitive impairment, MCI does not severely impair daily, social, or occupational functioning whereas dementia does.[5,6] While dementia worsens in nearly all patients,[5] MCI does not inevitably progress to dementia.[7–9] Many older adults with MCI live years[10]—almost a decade on average in one community-based study[11]—with good quality of life,[12,13] and face competing health risks of aging, namely CVD—the leading cause of death and serious morbidity in community-dwelling older adults with and without MCI.[11,14] Both MCI and dementia are risk factors for AIS.[15,16]

Differences in acute ischemic stroke (AIS) treatment by cognitive status are unclear but some studies have found less evidence-based care for patients with dementia.[17,18] Less is known about the quality of stroke care for patients with pre-existing MCI,[19] despite evidence in other diseases (i.e., acute myocardial infarction), that older adults with MCI might be under-treated.[20,21] Identifying under-treatment can inform policies and interventions to ensure older adults with MCI receive high-quality, guideline-concordant care.

We leveraged a US population-based stroke surveillance project with a measure of pre-stroke cognition to compare receipt of established, effective treatments after AIS across the

spectrum of cognitive status (pre-existing normal cognition, MCI, and dementia), and whether treatment differences persisted after adjusting for patient and stroke factors.

Methods

Requests for deidentified data should be sent to the corresponding author and are subject to existing institutional review board and data use agreements.

Study Population

The Brain Attack Surveillance in Corpus Christi (BASIC) project is a population-based stroke surveillance project conducted in a non-immigrant community of primarily Mexican Americans and non-Hispanic whites in Nueces County, Texas.[22] Details are described elsewhere.[22] Briefly, Nueces County is a predominantly urban location, where 95% of the population resides in the city of Corpus Christi on the Texas gulf coast.[23] Corpus Christi is situated greater than 150 miles from potential referral centers in San Antonio and Houston.[23] The geographic location and distance provide the opportunity for complete case capture of stroke in the county.[23] BASIC ascertains all cases of acute cerebrovascular disease presenting to the emergency department or directly admitted to any of the 7 hospitals in Nueces County through active and passive surveillance.

Trained abstractors identify stroke cases based on rigorous criteria. Stroke physicians validate stroke cases using source documentation following international clinical criteria.[24] At the time of their stroke hospitalization or soon after, patients (or proxies for patients unable to participate) complete an in-person, structured interview. Bilingual abstractors conducted the interview in English or Spanish per patient preferences. This project was approved by both the University of Michigan and the Corpus Christi Health Systems' Institutional Review Boards. All subjects or their proxies provided written informed consent.

We identified 929 BASIC participants with AIS between November 2008 through December 2013 who completed the baseline interview and had complete outcome information. Of these, we excluded 92 individuals missing information on pre-stroke cognitive status and one individual missing information on the primary outcome (Supplement eFigure I). Only the first AIS captured in BASIC for each patient was included.

Measurement of Outcomes

The primary outcome was a composite quality measure, calculated by dividing the number of treatments that a patient received by the number of treatments they were eligible to receive. Trained BASIC abstractors collected data on receipt of AIS treatments and procedures by reviewing the patient's medical records. Inter-rater reliability was high.[25] We selected effective treatments and procedures after AIS recommended by clinical practice guidelines available at the time when data were collected (2008–2013)[26,27] and measured in BASIC. AIS treatments were: 1) intravenous tissue plasminogen activator (t-PA) administered, 2) antithrombotic therapy by end of hospital day 2, 3) deep venous thrombosis prophylaxis, 4) assessed for rehabilitation, 5) discharged on antithrombotic therapy, 6), discharged on lipid-lowering therapy, and 7) discharged on anticoagulation therapy for atrial fibrillation.

The composite quality measure score ranges between 0 and 1, with values closer to 1 indicating greater receipt of the treatments. The composite quality score was not normally distributed and was right-skewed with some participants receiving 100% of the treatments. Based on the distribution of the data, we classified the composite quality score into three categories resulting in an ordinal 3-level composite quality measure (values of <0.75, 0.75–0.99, and 1.0) corresponding to the percentage of treatments received.

Secondary outcomes included a binary defect-free score defined as a patient receiving all treatments in the composite quality measure they were eligible to receive, the individual treatments, and three procedures after AIS: 1) brain magnetic resonance imaging only, 2) carotid artery imaging (carotid ultrasound, computed tomography angiography of neck, or magnetic resonance angiography of neck), and 3) echocardiogram (transthoracic or transesophageal).

Cognitive Status

Trained BASIC interviewers measure pre-stroke cognitive status in all AIS cases using the short form of the Informant Questionnaire on Cognitive Decline in the Elderly (IQCODE) obtained from an informant at the baseline interview. The short form of the IQCODE is a validated instrument to assess pre-stroke cognitive status[28,29] has been validated in Spanish, [30] and has been shown to be relatively unaffected by education level.[29] It asks an informant to report on changes in functional and cognitive status over time and, in this case, focuses on the pre-stroke time period. We classified patients as having pre-stroke normal cognition (IQCODE score ≤3), pre-stroke MCI (IQCODE score >3 or <3.44), and pre-stroke dementia (IQCODE score ≥3.44 or medical record documentation of diagnosis of dementia or Alzheimer's disease). The cut points for these categories are based on previous stroke research and increase the sensitivity of the diagnosis of MCI and dementia.[28,31]

Covariates

Covariates were measured at baseline using chart abstraction except race/ethnicity, education, and modified Rankin score (mRS) were collected by interview. Socio-demographics included age, sex, race/ethnicity, and education. Clinical factors included smoking status, alcohol consumption, body mass index (BMI), history of stroke/transient ischemic attack, and comorbidity. Comorbidity was measured using a composite score based on 11 major health conditions (coronary artery disease or myocardial infarction, atrial fibrillation, heart failure, cancer, chronic obstructive pulmonary disease, diabetes, end-stage renal disease, epilepsy, high cholesterol, hypertension, Parkinson's disease). Additional factors included pre-stroke functional status measured by the mRS, initial National Institutes of Health Stroke Severity (NIHSS) score, and do not resuscitate (DNR) status. Covariate measurement is described in the Online Supplement.

Statistical Analysis

We followed a pre-specified analysis plan. We performed descriptive and bivariate statistics. Because the primary outcome was an ordinal variable, we tested for associations between pre-existing cognitive status and the three-level composite quality measure (<0.75, 0.75–0.99, 1.0) using ordinal logistic regression (also known as cumulative logit or proportional

odds model) before and after adjusting for patient characteristics. This ordinal logistic regression model assumes that each explanatory variable exerts the same effect on the cumulative logit (i.e., the model satisfies the proportional odds assumption). We tested and found no evidence that the proportional odds assumption was violated.

For the primary outcome, we fitted a series of nested models. **Model M1** was the base model that included cognitive status only as a covariate. When building the best model (**Model M2**), we considered for inclusion as covariates several demographic, socioeconomic clinical factors detailed in Table 1. To select the best model, we compared pairs of nested models using the likelihood ratio test. The final parsimonious **Model M2** included pre-existing cognitive status (normal cognition, MCI, dementia), age, sex, race/ethnicity, education, comorbidity score, and BMI. After we built **Model M2**, we used multiple imputation[32] for missing values of the following covariates: marital status (n=1), education (n=2), BMI (n=6) and DNR status (n=68). To assess whether NIHSS, DNR, and prestroke mRS explained any of the association between pre-existing cognitive status and the outcomes, we then performed an analysis (**Model M3**) adding NIHSS, DNR, and prestroke mRS to the parsimonious **Model M2**.

We tested for associations between pre-existing cognitive status and the secondary outcomes before and after adjustment for patient and stroke factors using logistic regression. Statistical significance for all tests was set at $P<0.05$ (2-sided). We performed all analyses using Stata 15.1 (Stata Corporation, College Station, TX).

Sensitivity Analyses—Categorizing patients into three groups of pre-stroke cognitive status (ordinal scale; values, normal cognition, MCI, and dementia) based on the IQCODE score (a continuous variable) can result in loss of information and decreased statistical power to detect an association between pre-stroke cognitive status and receipt of stroke care. So, we repeated the primary analysis treating the IQCODE score as a continuous covariate to determine the extent to which higher IQCODE scores (worse cognition) are associated with lower care quality using the composite quality measure. To examine possible temporal differences in the quality of stroke care during the study period between cognitive status groups, we repeated the analyses by testing a years of stroke hospitalization (study time) covariate and cognitive status by study time interaction in the appropriate regression models. We combined study years into two-year periods because individual years had small numbers within cognitive status groups relative to the number of covariates in the models.

Results

The study sample included 836 participants. Table 1 presents patient characteristics. Among patients with AIS, 42% had normal cognition (47% women; median age [IQR], 65 [56–76] years), 32% had MCI (54% women; median age, 70 [60–78] years), 26% had dementia (56% women; median age, 78 [64–85] years). Stroke patients with greater pre-stroke cognitive impairment were more likely to be older, female, and privately insured; they were also more likely to have lower BMI, history of stroke/TIA, greater comorbidity, greater stroke severity, DNR status, and greater pre-stroke functional impairment. Included participants, compared with excluded participants, were more likely to have younger age,

single marital status, current smoking status, government insurance, and lower mean pre-stroke modified Rankin score (Supplement eTable I).

Composite Quality Measure (Primary outcome)

Composite quality scores were similar between cognitively normal patients and patients with pre-existing MCI but significantly lower in patients with pre-existing dementia (Table 1). In unadjusted analyses, compared to cognitively normal patients, patients with pre-existing MCI had similar cumulative odds (ucOR=0.99, P=0.92) and patients with pre-existing dementia had 36% lower cumulative odds of receiving the composite quality measure (ucOR=0.64, P=0.005) (**Model M1,** Table 2). However, in analysis adjusting for patient age, sex, race/ethnicity, education, comorbidity score, and BMI, the dementia-quality association became non-significant (acOR=0.76, P=0.11) (**Model M2,** Table 2). Further adjustment for NIHSS score, DNR status, and mRS score did not substantially change the dementia-quality association (acOR=0.79, P=0.19) (**Models M3** Table 2). Patient factors associated with lower cumulative odds of receiving the composite quality measure were female sex (acOR=0.74, P=0.03) and greater comorbidity (acOR=0.88 per 1-point increase, P=0.01); whereas higher BMI was associated with greater cumulative odds of receiving the outcome (acOR=1.03 per 1-unit increase, P=0.01) (Supplement eTable II).

Defect-free Quality Score and Individual Treatments and Procedures

Patients with Pre-existing MCI versus Cognitively Normal Patients—Results of the secondary outcomes were consistent with the results of the primary outcome. After AIS, 44% of patients with pre-existing dementia and 55% of patients with pre-existing MCI or normal cognition received defect-free care. In unadjusted analyses, patients with pre-existing MCI, compared with cognitively normal patients, received most individual treatments and procedures as frequently except they received two procedures less frequently: assessment for rehabilitation (acOR=0.35, P=0.035) and echocardiogram (acOR=0.48, P<0.001) (Tables 1 and **Model M1,** Table 2). After adjusting for age, sex, race/ethnicity, education, comorbidity score, and BMI, pre-existing MCI remained negatively associated with receipt of rehabilitation assessment (acOR=0.29, P=0.018) and echocardiogram (acOR=0.47, P<0.001) (**Model M2,** Table 2). With further adjustment for NIHSS score, DNR status, and mRS score, pre-existing MCI became negatively associated with receipt of intravenous t-PA (acOR=0.36, P=0.04) and remained negatively associated with receipt of rehabilitation assessment (acOR=0.28, P=0.016) and echocardiogram (acOR=0.48, P<0.001) (**Model M3,** Table 2).

Patients with Pre-existing Dementia versus Cognitively Normal Patients—Before adjustment, patients with pre-existing dementia, compared with cognitively normal patients, were less likely to receive defect-free care (ucOR=0.63, P=0.007) as well as five treatments and procedures: antithrombotic therapy by hospital day 2 (ucOR=0.27, P=0.001), lipid-lowering therapy at discharge (ucOR=0.47, P=0.003), brain MRI (ucOR=0.60, P=0.05), carotid imaging (ucOR=0.56, P=0.04), and echocardiogram (ucOR=0.38, P<0.001) (Tables 1 and **Model M1,** Table 2). After adjusting for age, sex, race/ethnicity, education, comorbidity score, and BMI, pre-existing dementia remained negatively associated with receipt of antithrombotic therapy by hospital day 2 (acOR=0.32, P=0.008), lipid-lowering

therapy at discharge (acOR=0.50, P=0.01), and echocardiogram (acOR=0.39, P<0.001) but no longer associated with receipt of defect-free care (acOR=0.76, P=0.12), brain MRI (acOR=0.83, P=0.50) and carotid imaging (acOR=0.60, P=0.09) (**Model M2,** Table 2). The addition of NIHSS score, DNR status, and mRS score in **Model M3** partially attenuated the association between pre-existing dementia and receipt of antithrombotic therapy by hospital day 2 (acOR= 0.39, P=0.04), and fully attenuated the association between dementia and receipt of lipid-lowering therapy at discharge (acOR=0.61, P=0.10) but did not change the association between dementia and receipt of echocardiogram (acOR=0.42, P<0.001) (**Model M3,** Table 2).

Predictors—Female sex, greater comorbidity, and lower BMI were associated with lower odds of receiving some secondary outcomes (Supplement eTables II and III). Greater stroke severity was associated with greater odds of receiving intravenous t-PA, rehabilitation assessment, and anticoagulation for atrial fibrillation at discharge.

Sensitivity Analyses

Results were similar in analyses examining the association between continuous IQCODE score and the composite quality measure (Supplement eTable IV). The results suggest improvement in the quality of stroke care over study time in all three cognitive status groups of stroke patients. However, we found no evidence that the improvement in the quality of stroke care over time differed between patients with dementia, MCI and cognitively normal patients (P for cognitive status by-study time period interaction was 0.41 for the composite quality measure and 0.58 for the defect-free quality score). The addition of study time to the models did not change results for the primary effect of interest, the association between pre-existing cognitive status and quality of stroke care (Supplement eTable V).

Discussion

In this population-based sample of Mexican American and non-Hispanic white AIS patients 45 years or older, we found that most (58%) were cognitively impaired before stroke with approximately one-third of patients having pre-existing MCI and one-quarter having pre-existing dementia. Neither pre-existing MCI nor pre-existing dementia were associated with the primary outcome, the composite quality measure, after accounting for patient factors namely female sex, greater comorbidity, and lower BMI. However, only 44% of patients with pre-existing dementia and 55% of patients with MCI and normal cognition received defect-free care after AIS. We found evidence that pre-existing MCI was associated with lower odds of receiving only 3 of 10 individual treatments and tests (intravenous t-PA, assessment for rehabilitation, and echocardiogram) and pre-existing dementia was associated with lower odds of receiving only 2 of 10 (anti-thrombotic therapy by hospital day 2 and echocardiogram) independent of patient factors.

Previous studies have found that patients with pre-existing dementia receive less guideline-concordant care after AIS.[17,18] In one study, patients with pre-existing dementia were less likely than non-demented patients to receive some treatments after AIS including IV t-PA (even in the absence of recognized contraindications), admission to stroke unit, management by stroke team, statin at discharge, and anticoagulation for atrial fibrillation at discharge in

unadjusted analyses; however, this analysis did not perform multivariable adjustment.[17] Our study extends this prior work by adjusting for patient and stroke factors and finding few differences in receipt of AIS care between patients with pre-existing dementia and those with normal cognition independent of patient factors. Less is known about the relationship between pre-existing MCI and receipt of guideline-concordant care after AIS. In a study[19] using data from the nationally representative Health and Retirement Study (HRS), patients with pre-existing MCI, compared to cognitively normal patients, had 39% lower cumulative odds of receiving the composite quality measure; however, this association became non-significant after adjusting for patient and hospital factors, consistent with our results. Our finding that 31.9% of patients with AIS had pre-existing MCI are consistent with results from the nationally representative HRS showing that 26.9% of patients with AIS had pre-existing MCI based on longitudinal cognitive assessments.[19] Taken together, these findings suggest that up to one in three patients with AIS has pre-existing MCI.

Although we found no evidence of an independent association between pre-existing cognitive status and the composite quality measure, we found evidence that pre-existing MCI and dementia are independently associated with lower odds of receiving some individual treatments and procedures after AIS. If the observed differences between patients with pre-existing MCI and normal cognition in the receipt of intravenous t-PA and assessment for rehabilitation as well as the observed differences between patients with pre-existing dementia and normal cognition in receipt of anti-thrombotic therapy are causal, then they would be clinically significant. Direct randomized controlled trials have shown that intravenous t-PA reduces mortality and functional disability, rehabilitation reduces functional disability, and anti-thrombotic therapy reduces stroke recurrence. Our finding of lower use of echocardiogram after AIS in patients with MCI and dementia is consistent with results after acute myocardial infarction.[21] Given that recent guidelines[26] suggest that not every AIS patient needs an echocardiogram, it is possible that patients with normal cognition were over-tested with echocardiogram rather than that patients with MCI and dementia were under-tested.

It is encouraging that we found limited evidence that pre-existing MCI and dementia are independently associated with receiving less care after AIS in this community. Studies have shown that patients with pre-existing MCI or dementia have similar benefits and risks of AIS treatments (including IV t-PA) as patients with normal cognition.[28,31,33] Prominent experts recommend that all older adults, except those with advanced dementia or limited life expectancy, receive effective treatments as a minimum standard for acceptable stroke care.[34,3536] While more research on the influence of pre-stroke MCI and dementia on treatment outcomes and physician decision-making is needed, there is currently no evidence to support withholding evidence-based treatments for acute management and secondary prevention of AIS in patients with MCI and dementia.[37]

Although we found that patients with pre-existing dementia, compared to cognitively normal patients, received the composite quality measure less frequently after AIS, this difference was largely explained by patients with dementia being more likely to be women and to have greater comorbidity and lower BMI, all factors associated with receiving less care.[25,38] It is meaningful that we found limited evidence of a causal association between pre-stroke

cognitive status and receipt of AIS care, but we did find evidence of associations between female sex, greater comorbidity, and lower BMI and receiving less AIS care. While other studies have also found that women[38] and those with greater comorbidity[25] receive less care, these results raise questions about whether these groups are being "under-treated" for AIS and whether there are "appropriate" reasons for these patient groups to receive less care. Although the reasons for the BMI-quality association are uncertain, providers might recommend less AIS care to patients with lower BMI because studies show that patients with lower BMI have poorer stroke outcomes,[39] and lower BMI might be a proxy for worse disease severity (including for dementia) and poor health status.

Our study has several strengths. This is a well characterized community-based cohort with excellent capture of stroke cases in the county. Trained abstractors identified stroke cases and also abstracted information from the medical chart using rigorous methods. Stroke cases were validated by stroke physicians using source documentation and standardized clinical criteria. We accounted for eligibility to receive the treatments and procedures. We were able to perform risk-adjustment for stroke severity, DNR status, and mRS level. This additional risk-adjustment explained the association between pre-existing dementia and lipid-lowering therapy and also unmasked the association between pre-existing MCI and intravenous t-PA.

Our study has limitations. Although our definition of MCI is based on the IQCODE without a full clinical evaluation, the prevalence of pre-existing MCI in patients with AIS is similar to MCI prevalence in an HRS study using longitudinal cognitive assessments and cut-points based on in-depth, in-home, neuropsychological and clinical assessments as well as expert clinician adjudication from the Aging, Demographics, and Memory Study, an HRS dementia sub-study.[19] Still, misclassification of cognitive status is possible. Misclassifying cognitively normal patients as having MCI or dementia would reduce our ability to detect treatment differences by MCI or dementia status. We did not have information on delirium, stroke complications, or the appropriateness of the use of AIS treatments. While we adjusted for comorbidity count, we did not have measures of the severity of comorbid diseases. Approximately 10% of stroke participants did not have the IQCODE. We did not adjust for multiple comparisons. The results of the secondary outcomes might require confirmatory analysis. Given a small number of events relative to the number of covariates, the results of the adjusted models for receipt of intravenous t-PA and anticoagulation for atrial fibrillation at discharge should be interpreted with caution. Although the differences between the 3 pre-stroke cognitive status groups might be less distinct than those characterized by the IQCODE cut-points, we employed IQCODE cut-points used in previous studies and results were similar in analyses using IQCODE score as a continuous variable.

Conclusions

Our study has clinical and policy implications. Although prominent organizations[26] recommend treatments and procedures after AIS, we found that only 44–55% of patients received defect-free quality care after AIS. While the quality of stroke care improved over time during the study period, our findings suggest that there is substantial room for improvement of AIS care in many individuals, especially patients with dementia, women, and those with greater comorbidity. Our study suggests a scientific need to better understand

why patients in the community do not receive standard treatments and procedures after AIS and barriers to the delivery of high-quality care in order to inform interventions tailored to stroke patients and clinical care. The critical need is that individuals receive standard, effective treatments and procedures after AIS. These results also suggest that disparities in receipt of some individual treatments and procedures after AIS between patients with pre-existing MCI and dementia and those with normal cognition might contribute to differences in post-stroke outcomes such as functional disability and recurrent stroke.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Non-standard Abbreviations and Acronyms

acOR	adjusted cumulative odds ratio
AIS	acute ischemic stroke
BASIC	Brain Attach Surveillance in Corpus Christi
BMI	body mass index
CVD	cardiovascular disease
DNR	do not resuscitate
HRS	Health and Retirement Study
IQCODE	Informant Questionnaire on Cognitive Decline in the Elderly
IQR	interquartile range
IV t-PA	intravenous tissue plasminogen activator
MCI	mild cognitive impairment
mRS	modified Rankin score

NIHSS	National Institutes of Health Stroke Severity
ucOR	unadjusted cumulative odds ratio

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Table 1:

Characteristics and Outcomes of Stroke Patients by Pre-existing Cognitive Status

Characteristics	Stroke Patients with Pre-existing Normal Cognition (N=352)	Stroke Patients with Pre-existing MCI (N=267)	Stroke Patients with Pre-existing Dementia (N=217)	P MCI vs normal cognition	P Dementia vs normal cognition
Age, median (interquartile interval), years	65 (56–76)	70 (60–78)	78 (64–85)	0.001	<0.001
Women, n (%)	164 (47)	145 (54)	122 (56)	0.06	0.03
Race/ethnicity, n (%)					
Non-Hispanic White	103 (29)	96 (36)	77 (36)	0.16	0.12
Mexican American	228 (65)	153 (57)	122 (56)		
Other	21 (6)	18 (7)	18 (8)		
Marital status, n (%)					
Married/living with partner	187 (53)	135 (51)	99 (46)	0.56	0.08
Single	165 (47)	131 (49)	118 (54)		
Education (years), n (%)					
<12	132 (38)	93 (35)	92 (43)	0.79	0.45
12	99 (28)	79 (29)	54 (25)		
13+	121 (34)	95 (36)	69 (32)		
Insurance, n (%)					
Government	87 (25)	66 (25)	82 (38)	0.49	<0.001
Private	220 (62)	175 (65)	128 (59)		
None	45 (12)	26 (10)	7 (3)		
Smoking status, n (%)				0.89	0.09
Never	226 (64)	167 (63)	155 (71)		
Former	46 (13)	35 (13)	29 (14)		
Current	80 (23)	65 (24)	33 (15)		
Excessive alcohol use, n (%)	26 (7)	27 (10)	10 (5)	0.23	0.19
Body mass index, median (interquartile interval), kg/m^2	28.9 (25.6–33.6)	28.2 (25.1–32.6)	26.6 (23.6–31.9)	0.12	<0.001
History of stroke, n (%)	82 (23)	81 (30)	90 (41)	0.05	<0.001
Comorbidity score, median (interquartile interval), points	2 (1–3)	2 (1–3)	2 (1–3)	0.19	<0.001
Median NIHSS at baseline (interquartile interval), points	4 (2–8)	4 (2–7)	5 (2–9)	0.56	0.04
DNR status (n=768) , n (%)	5 (2)	17 (7)	17 (9)	0.001	<0.001
Prestroke modified Rankin Score, median (interquartile interval), points	1 (0–2)	2 (0–2)	3 (1–4)	0.02	<0.001
Receipt of composite quality measure (primary outcome)					
Composite quality score, median (interquartile range)	1 (0.75–1)	1 (0.75–1)	0.83 (0.67–1)	0.87	0.008
Composite quality score classified as three-level variable				0.99	0.02

Characteristics	Stroke Patients with Pre-existing Normal Cognition (N=352)	Stroke Patients with Pre-existing MCI (N=267)	Stroke Patients with Pre-existing Dementia (N=217)	P MCI vs normal cognition	P Dementia vs normal cognition
<75% of process measures received	78 (22)	60 (22)	66 (30)		
75%–99% of process measures received	79 (23)	60 (22)	56 (26)		
100% of process measures received	195 (55)	147 (55)	95 (44)		
Receipt of defect-free quality score (secondary outcome)					
Defect-free quality score (100% of process measures received), n (%)	195 (55)	147 (55)	95 (44)	0.93	0.007
Receipt of individual treatments and procedures (secondary outcomes) (N = patients eligible for the treatment or procedure; n = patients who received the treatment or procedure)					
Intravenous t-PA, n/N (%) (N=140)	34/61 (56)	16/42 (38)	15/37 (41)	0.08	0.15
Antithrombotic therapy by end of hospital day 2, n/N (%) (N=689)	277/287 (97)	209/222 (94)	159/180 (88)	0.20	0.001
Deep venous thrombosis prophylaxis, n/N (%) (N=521)	175/214 (82)	125/151 (83)	128/156 (82)	0.81	0.95
Assessed for rehabilitation, n/N (%) (N=702)	284/290 (98)	214/227 (94)	180/185 (97)	0.03	0.65
Antithrombotic therapy at discharge, n/N (%) (N=818)	272/342 (80)	216/263 (82)	159/213 (75)	0.42	0.18
Lipid-lowering therapy at discharge, n/N (%) (N=577)	201/238 (84)	158/190 (83)	107/149 (72)	0.72	0.003
Anticoagulation therapy for atrial fibrillation at discharge, n/N (%) (N=162)	41/55 (75)	38/50 (76)	38/57 (67)	0.86	0.36
Brain MRI (N=768) , n (%)	285/322 (89)	209/248 (84)	163/198 (82)	0.14	0.05
Carotid imaging (N=768), n (%)	295/322 (92)	222/248 (90)	170/198 (86)	0.39	0.04
Echocardiogram (N=768), n (%)	273/322 (85)	180/248 (73)	135/198 (68)	<0.001	<0.001

Abbreviations: DNR, do-not-resuscitate. MCI, mild cognitive impairment. MRI, magnetic resonance imaging. NIHSS, National Institute of Health Stroke Scale. t-PA, tissue plasminogen activator. Comorbidity was measured using a composite score based on 11 major health conditions (coronary artery disease or myocardial infarction, atrial fibrillation, heart failure, cancer, chronic obstructive pulmonary disease, diabetes, end-stage renal disease, epilepsy, high cholesterol, hypertension, Parkinson's disease).

P-value based on the chi-square test for categorical variables and Kruskal Wallis non-parametric test for continuous variables.

Table 2:

Unadjusted and Adjusted Odds Ratios (95% CIs) for Receiving Composite Quality Score, Defect-Free Quality Score, and Individual Treatments and Procedures after Acute Ischemic Stroke by Cognitive Status

	Base model (M1): Unadjusted cumulative odds ratios (95% CI) (n=836)		**Parsimonious model (M2): Adjusted cumulative odds ratios (95% CI) (n=836)**		**Full model (M3): Adjusted cumulative odds ratios (95% CI) (n=836)**	
	MCI vs normal cognition	**Dementia vs normal cognition**	**MCI vs normal cognition**	**Dementia vs normal cognition**	**MCI vs normal cognition**	**Dementia vs normal cognition**
Primary outcome						
Composite quality measure (ordinal scale with 3 levels)	0.99 (0.73–1.34) P=0.92	**0.64 (0.46–0.88) P=0.005**	1.07 (0.78–1.45) P=0.69	0.76 (0.54–1.06) P=0.11	1.06 (0.77–1.45) P=0.72	0.79 (0.55–1.12) P=0.19
Secondary outcomes	**Base model (M1): Unadjusted odds ratios (95% CI)**		**Parsimonious model M2: Adjusted odds ratios (95% CI)**		**Full model (M3): Adjusted odds ratios (95% CI)**	
	MCI vs normal cognition	**Dementia vs normal cognition**	**MCI vs normal cognition**	**Dementia vs normal cognition**	**MCI vs normal cognition**	**Dementia vs normal cognition**
Defect-free quality score (yes vs no)	0.99 (0.72–1.36) P=0.93	**0.63 (0.45–0.88) P=0.007**	1.08 (0.77–1.49) P=0.66	0.76 (0.53–1.08) P=0.12	1.07 (0.77–1.49) P=0.67	0.76 (0.52–1.11) P=0.16
Intravenous t-PA (N=140) *	0.49 (0.22–1.09) P=0.08	0.54 (0.24–1.24) P=0.15	0.48 (0.21–1.13) P=0.09	0.52 (0.21–1.25) P=0.14	**0.36 (0.14–0.96) P=0.04**	0.84 (0.30–2.35) P=0.74
Antithrombotic therapy by end of hospital day 2 (N=689)	0.58 (0.25–1.35) P=0.21	**0.27 (0.13–0.60) P=0.001**	0.65 (0.28–1.54) P=0.33	**0.32 (0.14–0.74) P=0.008**	0.68 (0.29–1.63) P=0.39	**0.39 (0.16–0.96) P=0.04**
Deep venous thrombosis prophylaxis (N=521)	1.07 (0.62–1.85) P=0.81	1.02 (0.60–1.74) P=0.95	1.04 (0.59–1.84) P=0.89	0.97 (0.55–1.71) P=0.91	1.05 (0.59–1.85) P=0.87	1.01 (0.55–1.87) P=0.97
Assessed for rehabilitation (N=702)	**0.35 (0.13–0.93) P=0.035**	0.76 (0.23–2.53) P=0.66	**0.29 (0.11–0.81) P=0.018**	0.52 (0.15–1.82) P=0.30	**0.28 (0.10–0.79) P=0.016**	0.42 (0.11–1.56) P=0.19
Antithrombotic therapy at discharge (N=818)	1.18 (0.78–1.78) P=0.42	0.76 (0.51–1.14) P=0.18	1.29 (0.85–1.96) P=0.23	0.90 (0.59–1.38) P=0.63	1.26 (0.83–1.92) P=0.28	0.88 (0.56–1.39) P=0.59
Lipid-lowering therapy at discharge (N=577)	0.91 (0.54–1.52) P=0.72	**0.47 (0.28–0.77) P=0.003**	0.97 (0.57–1.64) P=0.90	**0.50 (0.29–0.85) P=0.01**	1.01 (0.59–1.72) P=0.97	0.61 (0.34–1.10) P=0.10
Anticoagulation therapy for atrial fibrillation at discharge (N=162) *	1.08 (0.44–2.63) P=0.86	0.68 (0.30–1.55) P=0.36	1.16 (0.45–2.97) P=0.76	0.64 (0.25–1.62) P=0.35	1.13 (0.42–3.00) P=0.81	0.72 (0.27–1.92) P=0.51

Brain MRI (N=768)	0.70 (0.43–1.13) P=0.14	**0.60** **(0.37–1.0)** **P=0.049**	0.78 (0.47–1.29) P=0.33	0.83 (0.49–1.42) P=0.50	0.80 (0.48–1.33) P=0.39	0.96 (0.55–1.74) P=0.96
Carotid imaging (N=768)	0.78 (0.44–1.38) P=0.39	**0.56** **(0.32–0.97)** **P=0.04**	0.81 (0.46 – 1.43) P=0.47	0.60 (0.33–1.09) P=0.09	0.80 (0.45–1.43) P=0.46	0.66 (0.35–1.24) P=0.20
Echocardiogram (N=768)	**0.48** **(0.31–0.72)** **P<0.001**	**0.38** **(0.25–0.59)** **P<0.001**	**0.47** **(0.31–0.72)** **P<0.001**	**0.39** **(0.25–0.60)** **P<0.001**	**0.48** **(0.32–0.73)** **P<0.001**	**0.42** **(0.26–0.67)** **P<0.001**

Abbreviations: MCI, mild cognitive impairment.

Composite quality measure (primary outcome) was calculated by dividing the number of performance measures that a patient received by the number of measures a patient was eligible to receive. This score ranges between 0 and 1, with values closer to 1 implying better adherence to the performance measures. Process measures of ischemic stroke treatment were 1) intravenous t-PA administered, 2) antithrombotic therapy by end of hospital day 2, 3) deep venous thrombosis prophylaxis, 4) assessed for rehabilitation, 5) discharged on antithrombotic therapy, 6), discharged on lipid-lowering therapy, and 7) discharged on anticoagulation therapy for atrial fibrillation. Defect-free score was defined as a patient receiving all of the performance measures they were eligible to receive.

Covariates used in Models M1–M3

Model M1 (Base model): pre-existing cognitive status only (normal cognition, MCI, dementia).

Model M2: covariates in Model M1 + age, sex, race/ethnicity, education, comorbidity score, and body mass index.

Model M3: covariates in Model M2 + NIHSS score, DNR status, and mRS score

* Given a small number of events relative to the number of covariates the results of the adjusted models for these process measures should be interpreted with caution.