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Comprehensive versus consultative rehabilitation services postacute stroke: Outcomes differ

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Abstract—Comprehensive rehabilitation services after acute stroke have been shown efficacious in European trials; however, their effectiveness in everyday practices in the United States is unknown. We compared outcomes of veteran patients provided with comprehensive rehabilitation with those provided with consultative rehabilitation services after acute stroke using propensity scores. Outcomes included change in patients' physical and cognitive independence after rehabilitation, discharge to home as opposed to other settings, and 1-yr after hospital discharge survival. Of the 2,963 patients in the study, 683 (23.1%) received comprehensive rehabilitation while the remaining patients received consultative services. We found, after propensity adjustment, that those who received comprehensive rehabilitation compared with consultative gained on average 12.8 (95% confidence interval [CI]: 9.1 to 16.5) more points of physical independence on a 78-point scale and gained 1.5 (95% CI: 0.8 to 2.2) more points of cognitive independence on a 30-point scale. The likelihoods of discharge to home from the hospital (odds ratio [OR] = 1.61, 95% CI: 1.07 to 2.44) and 1 yr posthospital discharge survival (OR = 1.79, 95% CI: 1.25 to 2.56) were significantly higher among those who received comprehensive rehabilitation. Among patients hospitalized for acute stroke, comprehensive rehabilitation services are associated with greater recovery of physical and cognitive independence, improved home discharge likelihood, and improved 1 yr survival.

Key words: acute stroke, cognitive independence, function, home discharge, outcomes, propensity risk score, rehabilitation services, stroke, survival, veterans.

INTRODUCTION

An estimated 795,000 people in the United States experience a new or acute stroke annually, with an estimated cost of $73.7 billion in 2010 [1]. Nearly half of those surviving 6 mo remain with neurological deficits, which can cause disabilities, reduce quality of life, burden

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Abbreviations: CARF = Commission on Accreditation of Rehabilitation Facilities, CI = confidence interval, FIM = Functional Independence Measure, FSOD = Functional Status Outcomes Database, GEE = general estimating equation, ICD-9-CM = International Classification of Diseases-Ninth Revision-Clinical Modification, ICU = intensive care unit, IRF = inpatient rehabilitation facility, OR = odds ratio, PAC = postacute care, PM&R = physical medicine and rehabilitation, PTF = patient treatment file, SD = standard deviation, SRU = specialized rehabilitation unit, VA = Department of Veterans Affairs, VAMC = Department of Veterans Affairs Medical Center, VHA = Veterans Health Administration.

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family members, and cause premature institutionalization. Among 108 patients with acute stroke 65 yr and older from the Framingham study, 50 percent had residual hemiparesis, 31 percent were unable to walk without assistance, 26 percent were dependent in activities of daily living, 19 percent had aphasia, and 26 percent were institutionalized at 6 mo poststroke [2].

Evidence primarily from Europe based on 41 trials involving 6,936 participants shows that interdisciplinary rehabilitation provided on an organized stroke unit compared with care on a general hospital ward leads to increased independency, less need for institutionalization, and increased survival after hospital discharge [3]. Although the benefits of comprehensive stroke unit care are clear from the European literature, the effectiveness of comprehensive services on dedicated bed sections during acute hospitalization as practiced in the United States is not well established.

Because comprehensive stroke rehabilitation supported by Medicare tends to be provided in inpatient rehabilitation facilities (IRFs) as separate postacute care (PAC) hospitalizations after acute hospital discharge, it is difficult to generalize findings of efficacy from European stroke units to U.S. rehabilitation services in IRFs. However, within the Veterans Health Administration (VHA), patients hospitalized for acute stroke are routinely assessed by interprofessional rehabilitation teams soon after hospital admission according to VHA clinical guidelines [4]. Following this assessment, some patients are transferred to specialized bed services within the acute hospitalization where they receive rehabilitation on discrete units analogous in comprehensiveness to the services provided in dedicated European stroke units. Other patients remain on nonrehabilitative hospital services where they receive consultative rehabilitation services analogous to general wards in the European studies [3]. Consequently, the VHA system provides an opportunity to study the effectiveness of rehabilitation services provided in the United States that more closely mirrors the European stroke model.

Taking advantage of the large integrated network of Department of Veterans Affairs (VA) hospitals, we compared the degree of functional recovery, home discharge versus other settings (extended care in a nursing home, discharge against medical advice, discharge to a non-VA hospital, and other), and 1 yr survival in patients who received comprehensive stroke rehabilitation on a dedicated bed section with those who received consultative rehabilitation during their acute hospitalization. We believe our study is the first attempt in the United States to compare the effectiveness of comprehensive and consultative stroke rehabilitation provided within an integrated health system.

METHODS

Setting and Patients

Included were the 85 VA medical centers (VAMCs) accredited by the Commission on Accreditation of Rehabilitation Facilities (CARF) during the study years. CARF accreditation certifies that facilities are capable of providing patients with quality integrated inpatient rehabilitation programs and ensures that facilities provide a similar standard of rehabilitation services. To better reflect the timeline structure of the European studies, we limited analyses to veterans whose inpatient rehabilitation began and finished during their acute hospitalizations.

Patient information was obtained from eight national VHA databases used to track the health status and healthcare utilization of veterans, including the patient treatment files (PTFs) (main, bed section, procedure), two outpatient care files (visit, event), the extended care file, the Beneficiary Identification Record Locator System death file, and the Functional Status Outcomes Database (FSOD) [5–8]. Extraction methods and databases descriptions have been previously reported [9–11].

Patients with hospital discharge dates between October 1, 2006, and September 30, 2008, receiving either comprehensive or consultative rehabilitation services during their index hospitalization with a principal diagnosis of a new acute stroke were included. A stroke diagnosis was based on specific International Classification of Diseases-Ninth Revision-Clinical Modification (ICD-9-CM) codes [12] being present in either the primary diagnosis field of the patients' PTF main or one or more PTF bed section record(s) indicating that stroke was the main reason for hospitalization. Based on findings of association with the receipt of rehabilitation services, we identified six categories of stroke: occlusion, embolism, or stenosis of the cerebral arteries (434.01, 434.11, 434.91); occlusion or stenosis of the precerebral arteries (433.01, 433.11, 433.21, 433.31, 433.81, 433.91); intracerebral hemorrhage (431.xx, 432.xx); subarachnoid hemorrhage (430.xx); acute, but ill-defined, cerebral vascular disease (436.xx); and transient cerebral ischemia (435.xx), which was included only if there was additional evidence of stroke indicating either hemiplegia, hemiparesis (342.xx), or one or more of the previously mentioned stroke codes present in secondary diagnostic fields. Patients with evidence of a previous stroke were excluded based on stroke codes being present in the PTF, outpatient care files, extended care file, or FSOD the year preceding the index hospitalization admission date.

We included veterans admitted with a principle diagnosis of new stroke, discharged alive from their acute hospitalization within a VAMC, who received and completed either comprehensive or consultative rehabilitation during that acute "index" hospitalization. Since our intent was to focus on the effect of rehabilitation services received during the index hospitalization, our analyses were limited to patients whose inpatient rehabilitation was completed prior to that hospital discharge date. There were 3,473 patients who met these inclusion criteria; of these, 2,963 were included in the analysis because 510 (14.7%) were missing initial (n = 47) or final (n = 463) functional status scores, so the main outcome of change in those patients' physical and cognitive independence could not be defined.

Patient Characteristics

Characteristics were age, sex, marital status, and living location before hospitalization. Stroke was grouped into six mutually exclusive and exhaustive categories as described previously. If there was evidence suggesting several stroke types, coding preference was given to bleeds and central nervous system involvement over occlusive and precerebral disease. Extent of paresis was categorized as bilateral, unilateral, or none.

Functional status was expressed as motor and cognitive Functional Independence Measure (FIM) scores rated at initial assessment by physical medicine and rehabilitation (PM&R) professionals and discharge from rehabilitation services [13]. These reliable [14] and psychometrically distinct motor (score range: 13–91) and cognitive (score range: 5–35) dimensions express severity of physical disability and cognitive or communication disability, respectively, with higher scores expressing greater independence [6].

In efforts to characterize underlying comorbidities, we recorded the presence of up to 30 comorbidities using diagnostic codes developed by Elixhauser et al. [15] and applied in other comparative studies [16]. We included ICD-9-CM procedure codes classified by the clinician authors [17]. Intensive care unit (ICU) stays and the number of bed sections where treatment occurred prior to initial rehabilitation assessment were included to assess complexity.

Functional recovery time was expressed as the number of days between the initial PM&R assessment and discharge from comprehensive or consultative rehabilitation services when initial and final functional status were measured.

Inpatient Rehabilitation Treatments

Comprehensive and consultative rehabilitation treatment services were compared. Patients were defined as the "comprehensive" group if admitted to a specialized rehabilitation unit (SRU) bed section during the index hospitalization. Like stroke units, rehabilitation in an SRU is considered highly organized and team-based. It includes a complex package of therapies as directed by a physician specialized in rehabilitation and is provided by multiple professional disciplines including physical therapists, kinesiotherapists, occupational therapists, and orthotics specialists. SRU beds are clustered in one discrete area of the hospital. High-intensity rehabilitation therapy is provided daily with the primary hospital goal shifting to functional restoration. While structurally similar to stroke units, SRUs are mixed rehabilitation bed sections where patients are rehabilitated for a variety of medical conditions or injuries.

Patients were defined as the lower-intensity "consultative" rehabilitation treatment group if they received only consultative rehabilitation during the index hospitalization. While the same types of professionals are available as in the SRUs, consultative rehabilitation is less formally organized. Functional restoration remains a secondary rather than primary goal, and patients remain in a nonrehabilitation bed section, typically medical or neurological bed sections. Consultative therapy, ranging in frequency from two visits to several visits per week, is less intense than comprehensive. The clinical decision to provide comprehensive or consultative rehabilitation occurs after initial assessment by the rehabilitation team.

Outcomes

Our primary outcomes were changes in patients' physical and cognitive functional independence obtained by subtracting motor and cognitive FIM scores (as described previously) at the initial poststroke assessment from those obtained during the final assessment from rehabilitation services. Secondary outcomes were discharge home from the hospitalization compared with other settings and 1 yr survival from the hospital discharge date. These four outcomes were selected because they represent commonly recommended and applied end points for stroke trials [18].

Analyses

Frequencies and proportions for categorical variables and mean ± standard deviation (SD) for continuous variables were applied to compare patients who received comprehensive versus consultative rehabilitation. The relationship between receipt of comprehensive or consultative rehabilitation and patient characteristics and all outcomes was addressed applying chi-square tests and Student *t*-tests. To reduce the effects of treatment selection bias, all factors believed to potentially influence clinicians' decisions to admit the patient to an SRU were included in a logistic regression model to estimate the likelihood of receiving comprehensive versus consultative rehabilitation. Specifically, predictor variables included demographics, motor and cognitive FIM scores at initial assessment, previous living circumstances, stroke type and extent of paresis, comorbidities, number of bed sections on which treatment occurred, hospital procedures and ICU stays occurring prior to the rehabilitation treatment decision point, and time between hospital admission and initial assessment. Clinically anticipated and statistically important interactions were added. The model yielded a propensity score for each patient that reflected the probability of him or her receiving comprehensive versus consultative rehabilitation.

Patients were then distributed into five groups according to propensity score quintiles. Because it is possible that the propensity scores or quintiles could not capture all the confounding introduced by some variables, propensity score quintiles, a dichotomous treatment variable (comprehensive vs consultative), and all variables were included in a model for each of the main and secondary outcomes. Backward selection was used to remove nonsignificant variables one at a time. Then, propensity score quintiles along with the dichotomous treatment variable and any variables that remained significant independent predictors after backward selection were included in a separate general estimating equation (GEE) model (SAS Institute Inc; Cary, North Carolina) for each outcome. GEE models were used to consider the clustering effects by VAMCs.

We performed two additional analyses. In the first analysis, we added recovery time as a continuous variable to the final propensity-adjusted outcome models recognizing that longer functional recovery times expressed as the number of days between initial and final functional assessment could have benefited the comprehensive treatment group. We did not treat it as the other confounders because recovery time was not observed at the study baseline, which is the initial assessment.

The second analysis estimated the effect of rehabilitation treatment-adjusting confounders directly in multivariable models without including the propensity score. The selection of variables was hypothesis-driven based on clinical plausibility and literature review of rehabilitation referral decision-making and the determinants of functional recovery [19–27], mortality [27–32], and home discharge following hospitalization [33–40]. It is generally recommended that propensity analysis be treated as the main analysis over traditional covariate adjustment analysis [41]. If the effects remain in the same direction and remained statistically significant in the primary propensity-adjusted analysis and the two additional analyses, we assumed that findings were robust.

RESULTS

Patient age was 67.9 ± 11.7 yr (mean ± SD), and 97.3 percent were male. Most patients were admitted from home (95.5%), with small minorities being transferred from non-VA hospitals or extended care facilities. Occlusion of cerebral arteries was the most common stroke type, and hypertension, diabetes, and arrhythmias were the most frequently recorded comorbidities (**Table 1**), with 1.8 percent receiving mechanical ventilation. Almost 17 percent required an ICU admission (**Table 1**). Total hospital stay was 14.3 ± 18.0 d.

A total of 683 (23.1%) patients received comprehensive rehabilitation, with the remaining patients receiving consultative rehabilitation. When compared with those who received consultative rehabilitation services, patients who had comprehensive rehabilitation at initial assessment were, on average, more physically and cognitively disabled and tended to have more comorbidities and procedures as reported previously. Time to initial comprehensive rehabilitation was 4.60 ± 6.58 d. Time to initial consultative rehabilitation was 1.90 ± 3.39 d, with 10 percent of patients hospitalized for 35 d or longer. Functional recovery time was 24.40 ± 17.36 d for the comprehensive group compared with 6.20 ± 11.06 d for those who received consultative therapy.

Table 2 shows patient outcomes by rehabilitation type. Overall motor and cognitive FIM changes were 11.49 ± 15.20 and 1.48 ± 4.16, respectively. Overall, 89.4 percent of patients were discharged to home. The remaining were discharged to a different setting, including 0.6 percent to a non-VA hospital, 8.4 percent to

Table 1.
Characteristics of patients included in study.

Characteristic	All Patients (*N* = 2,963)	Comprehensive Rehabilitation (*n* = 683, 23.1%)	Consultative Rehabilitation (*n* = 2,280, 76.9%)	*p*-Value
Patient-Level				
Age, yr (mean ± SD)	67.9 ± 11.65	67.1 ± 10.99	68.1 ± 11.83	0.03
Male, *n* (%)	2,883 (97.3)	667 (97.7)	2,216 (97.2)	0.51
Marital Status, *n* (%)				0.33
Not Married	1,700 (57.4)	403 (59.0)	1,297 (56.9)	
Married	1,263 (42.6)	280 (41.0)	983 (43.1)	
Living Location Before Hospitalization, *n* (%)				0.006
Extended Care	21 (0.7)	3 (0.4)	18 (0.8)	
Hospital	111 (3.7)	39 (5.7)	72 (3.2)	
Home	2,831 (95.5)	641 (93.9)	2,190 (96.1)	
Type of Stroke, *n* (%)				0.63
Occlusion of Cerebral Arteries	2,442 (82.4)	551 (80.7)	1,891 (82.9)	
Occlusion of Precerebral Arteries	136 (4.6)	34 (5.0)	102 (4.5)	
Intracerebral Hemorrhage	188 (6.3)	53 (7.8)	135 (5.9)	
Subarachnoid Hemorrhage	32 (1.1)	7 (1.0)	25 (1.1)	
Other CNS Hemorrhage	41 (1.4)	9 (1.3)	32 (1.4)	
Acute, TIA, and Nonspecific	124 (4.2)	29 (4.2)	95 (4.2)	
Type of Paresis, *n* (%)				<0.001
Lateral	2,299 (77.6)	605 (88.6)	1,694 (74.3)	
Bilateral	77 (2.6)	14 (2.0)	63 (2.8)	
None	587 (19.8)	64 (9.4)	523 (22.9)	
Functional Status (mean ± SD)				<0.001
Admission Motor FIM Score	51.4 ± 25.29	41.8 ± 18.50	54.26 ± 26.30	
Admission Cognitive FIM Score	25.7 ± 9.57	24.5 ± 8.02	26.0 ± 9.96	
Comorbidity, *n* (%)				
AIDS	23 (0.8)	4 (0.6)	19 (0.8)	0.52
Alcohol Abuse	392 (13.2)	98 (14.3)	294 (12.9)	0.33
Arrhythmias	733 (24.7)	166 (24.3)	567 (24.9)	0.76
Chronic Blood Loss Anemia	18 (0.6)	2 (0.3)	16 (0.7)	0.23
Chronic Pulmonary Disease	578 (19.5)	129 (18.9)	449 (19.7)	0.64
Coagulopathy	141 (4.8)	38 (5.6)	103 (4.5)	0.26
Congestive Heart Failure	464 (15.7)	101 (14.8)	363 (15.9)	0.47
Deficiency Anemias	474 (16.0)	96 (14.1)	378 (16.6)	0.11
Depression	580 (19.6)	159 (23.3)	421 (18.5)	0.005
Diabetes	1,275 (43.0)	313 (45.8)	962 (42.2)	0.09
Diabetes with Chronic Complications	480 (16.2)	125 (18.3)	355 (15.6)	0.09
Drug Abuse	257 (8.7)	55 (8.1)	202 (8.9)	0.51
Fluid and Electrolyte Disorders	383 (12.9)	104 (15.2)	279 (12.2)	0.04
Hypertension	2,599 (87.7)	612 (89.6)	1,987 (87.1)	0.09
Hypertension with Complication	36 (1.2)	17 (2.5)	19 (0.8)	0.001
Hypothyroidism	244 (8.2)	62 (9.1)	182 (8.0)	0.36
Liver Disease	131 (4.4)	29 (4.2)	102 (4.5)	0.80
Lymphoma	35 (1.2)	8 (1.2)	27 (1.2)	0.98

Table 1. (cont)
Characteristics of patients included in study.

Characteristic	All Patients (*N* = 2,963)	Comprehensive Rehabilitation (*n* = 683, 23.1%)	Consultative Rehabilitation (*n* = 2,280, 76.9%)	*p*-Value
Metastatic Cancer	61 (2.1)	13 (1.9)	48 (2.1)	0.74
Other Neurological Disorders	397 (13.4)	86 (12.6)	311 (13.6)	0.48
Paralysis	80 (2.7)	21 (3.1)	59 (2.6)	0.49
Peptic Ulcer Disease with Bleeding	73 (2.5)	11 (1.6)	62 (2.7)	0.10
Peripheral Vascular Disease	490 (16.5)	112 (16.4)	378 (16.6)	0.91
Psychoses	419 (14.1)	108 (15.8)	311 (13.6)	0.15
Pulmonary Circulation Disease	52 (1.8)	15 (2.2)	37 (1.6)	0.32
Renal Failure	205 (6.9)	46 (6.7)	159 (7.0)	0.83
Rheumatoid Arthritis	56 (1.9)	14 (2.0)	42 (1.8)	0.73
Solid Tumor Without Metastasis	495 (16.7)	96 (14.1)	399 (17.5)	0.03
Valvular Disease	242 (8.2)	57 (8.3)	185 (8.1)	0.85
Weight Loss	71 (2.4)	16 (2.3)	55 (2.4)	0.92
Treatment-Level				
Treatment and Test Administered Prior to Initial Assessment, *n* (%)				
Audiology and Ophthalmologic	2 (0.1)	0 (0.0)	2 (0.1)	0.44
Behavioral Health	24 (0.8)	8 (1.2)	16 (0.7)	0.23
Cardiac Diagnostic Imaging	735 (24.8)	202 (29.6)	533 (23.4)	0.001
Cardiac Surgery	11 (0.4)	3 (0.4)	8 (0.4)	0.74
Cardiopulmonary Critical Interventions	35 (1.2)	12 (1.8)	23 (1.0)	0.11
CNS Minimally Invasive Diagnostics	1,384 (46.7)	344 (50.4)	1,040 (45.6)	0.03
CNS Procedures and Invasive Diagnostics	13 (0.4)	3 (0.4)	10 (0.4)	0.99
Dental/Oral Surgery	3 (0.1)	1 (0.1)	2 (0.1)	0.67
Internal Organ Procedures and Diagnostic	1,123 (37.9)	247 (36.2)	876 (38.4)	0.29
Mechanical Ventilation	54 (1.8)	20 (2.9)	34 (1.5)	0.01
Musculoskeletal Diagnostic Imaging and Procedures	107 (3.6)	24 (3.5)	83 (3.6)	0.88
Peripheral Vascular Procedures and Diagnostic Imaging	95 (3.2)	26 (3.8)	69 (3.0)	0.31
Renal/Genitourinary Procedures	40 (1.3)	13 (1.9)	27 (1.2)	0.15
Renal Dialysis	17 (0.6)	4 (0.6)	13 (0.6)	0.96
Serious Nutritional Compromise	41 (1.4)	16 (2.3)	25 (1.1)	0.01
Swallowing Studies	31 (1.0)	14 (2.0)	17 (0.7)	0.003
Transfusion	49 (1.7)	13 (1.9)	36 (1.6)	0.56
Wound Care	3 (0.1)	1 (0.1)	2 (0.1)	0.67
Treatment-Related Factors				
No. of Hospital Service on Which Treatment Occurred (mean ± SD)	1.3 ± 0.66	1.8 ± 0.94	1.2 ± 0.46	<0.001
Time Between Hospital Admission and Initial Assessment, d (mean ± SD)	2.5 ± 4.49	4.6 ± 6.58	1.9 ± 3.40	<0.001
Recovery Time (length of stay in PM&R service), d (mean ± SD)	10.4 ± 14.91	24.4 ± 17.36	6.2 ± 11.06	<0.001
ICU Admission, *n* (%)	491 (16.6)	82 (12.0)	409 (17.9)	0.001

AIDS = acquired immune deficiency syndrome, CNS = central nervous system, FIM = Functional Independence Measure, ICU = intensive care unit, PM&R = physical medicine and rehabilitation, SD = standard deviation, TIA = transient ischemic attack.

extended care, 1.3 percent against medical advice, and 0.2 percent to other circumstances. Of the patients, 90 percent (90.1%) were alive 1-yr posthospital discharge.

For the propensity model, estimating the probability of receiving comprehensive versus consultative rehabilitation, the *C*-statistic was 0.86, and the propensity score ranged from 0 to 0.999.

After propensity adjustment and regression were applied to control for the remaining differences between the groups (**Table 3**), patients who received comprehensive

Table 2.
Unadjusted patient outcomes.

Outcome Variables	Overall (N = 2,963)	Comprehensive Rehabilitation (n = 683, 23.1%)	Consultative Rehabilitation (n = 2,280, 76.9%)	p-Value
Motor FIM Score Change (mean ± SD)	11.49 ± 15.20	24.92 ± 16.78	7.46 ± 12.07	<0.001*
Cognitive FIM Score Change (mean ± SD)	1.48 ± 4.16	3.00 ± 6.03	1.03 ± 3.27	<0.001*
Home Discharge, n (%)	2,650 (89.40)	611 (89.46)	2,039 (89.43)	0.98†
1 yr Survival, n (%)	2,669 (90.10)	634 (92.83)	2,035 (89.25)	0.006†

*Calculated by Student *t*-test.
†Calculated by chi-square test.
FIM = Functional Independence Measure, SD = standard deviation.

Table 3.
Association between receipt of comprehensive versus consultative rehabilitation services and outcomes in acute stroke.

Model	β Estimate (95% CI)		Odds Ratio (95% CI)	
	Motor FIM Score Change	Cognitive FIM Score Change	Home Discharge	1-yr Survival
Unadjusted	17.24 (13.24–21.24)*	1.86 (1.05–2.67)*	0.91 (0.66–1.27)†	1.58 (1.05–2.39)‡
Propensity Score Adjusted[a]	12.81 (9.05–16.57)*	1.51 (0.83–2.19)*	1.49 (1.04–2.14)‡	1.55 (1.09–2.20)‡
Propensity Score and Recovery Time Adjusted[ab]	11.39 (7.71–15.07)*	0.76 (0.17–1.36)§	1.61 (1.07–2.44)‡	1.79 (1.25–2.56)¶
Confounders Adjusted[c]	14.22 (10.67–17.76)*d	1.87 (1.18–2.56)*d	1.24 (0.88–1.74)†e	1.49 (0.99–2.24)**f

*$p \leq 0.0001$.
†$p \leq 0.001$.
‡$p < 0.01$.
§$p < 0.05$.
¶$p = 0.056$.
**$p > 0.05$.
[a]Covariates included in propensity model: age, sex, marital status, living location before admission, type of stroke, extent paresis, AMF, ACF, 30 Elixhauser et al. comorbidities variables [15], 19 hospital event variables, ICU stay before rehabilitation admission, LOS from hospital admission to rehabilitation admission, NBS before rehabilitation admission, AMF quadratic form, AMF cubic form, ACF quadratic form, ACF cubic form, LOS quadratic form, LOS cubic form, NBS quadratic form, NBS cubic form, interaction between age and AMF, interaction between age and ACF, interaction between age and LOS, interaction between age and NBS, interaction between AMF and LOS, interaction between ACF and LOS, interaction between NBS and LOS, interaction between AMC and NBS, and interaction between AFC and NBS.
[b]Additional covariate of recovery time was defined as number of days between initial and final PM&R assessment of function.
[c]Covariates added to adjust for confounding in all outcome models: age; age quadratic form; sex; type of stroke; extent paresis; AMF; ACF; comorbidities variables of chronic pulmonary disease, congestive heart failure, diabetes with chronic complications, metastatic cancer, pulmonary circulation disease, renal failure, and weight loss; and variables for treatment and test administered prior to initial assessment of mechanical ventilation, renal/genitourinary procedures, serious nutritional compromise, swallowing studies, and ICU stay before rehabilitation admission.
[d]Additional covariates to adjust for confounding in motor and cognitive FIM change models: marital status; comorbidities variables of arrhythmias, chronic blood loss anemia, deficiency anemias, depression, fluid and electrolyte disorders, other neurological disorders, paralysis, psychoses, renal failure, rheumatoid arthritis, and valvular disease; variables for treatment and test administered prior to initial assessment of cardiac diagnostic imaging, cardiac surgery, musculoskeletal diagnostic imaging and procedures, and transfusion; and LOS from hospital admission to rehabilitation admission.
[e]Additional covariates included to adjust for confounding in home discharge model: marital status; living location before admission; comorbidities variables of chronic blood loss anemia, depression, and paralysis; and variables for treatment and test administered prior to initial assessment of cardiac diagnostic imaging, cardiopulmonary critical interventions, internal organ procedures and diagnostic, and musculoskeletal diagnostic imaging and procedures.
[f]Additional covariates included to adjust for confounding adjusted in 1-yr survival model: living location before admission; comorbidities variables of arrhythmias, fluid and electrolyte disorders, liver disease, other neurological disorders, and valvular disease; and variables for treatment and test administered prior to initial assessment of cardiopulmonary critical interventions, internal organ procedures and diagnostic, renal dialysis, and transfusion.
ACF = admission cognitive FIM score, AMF = admission motor FIM score, CI = confidence interval, FIM = Functional Independence Measure, ICU = intensive care unit, LOS = length of stay, NBS = number of bed section, PM&R = physical medicine and rehabilitation.

compared with consultative rehabilitation had, on average, a 12.81-point (95% confidence interval [CI]: 9.05–16.57) greater increase in motor FIM (out of a 78-point range), a 1.51-point (95% CI: 0.83–2.19) greater increase in cognitive FIM (out of a 30-point range), a greater likelihood of discharge home (odds ratio [OR] = 1.49; 95% CI: 1.04–2.14), and better 1 yr survival (OR = 1.55; 95% CI: 1.09–2.20).

In the first additional analyses that added functional recovery time to the propensity adjustment, those who received comprehensive compared with those who received consultative rehabilitation showed similar treatment-related outcome differences.

In the second additional analyses that adjusted for confounders without estimating a propensity score, those who received comprehensive compared with those who received consultative rehabilitation were estimated as having even greater relative average increases in motor and cognitive FIM scores. The effect of comprehensive rehabilitation was marginally significant on the 1 yr survival outcome and not significant for the home discharge outcome.

DISCUSSION

After reducing the effects of treatment-selection bias, patients who received comprehensive rehabilitation achieved a level of physical functional independence that was on average 12.81 points higher as measured by the motor FIM when compared with those who received consultative rehabilitation. Recognizing that a difference of two or more motor FIM points is considered clinically important, an incremental gain of this magnitude is clearly meaningful [42–43]. Although receipt of comprehensive compared with consultative services was significantly associated with achievement of higher cognitive functional independence, the magnitude of difference for cognitive outcomes was smaller than for physical recovery. This finding is consistent with the goals of medical rehabilitation, which is often more focused on physical than on cognitive functional recovery. Our findings of a small comparative benefit support future efforts to look more closely at the benefits of cognitive rehabilitation. To date, evidence supporting memory, language, and cognitive rehabilitation is limited [44]. Our propensity-adjusted analyses also documented a survival advantage and greater odds of home discharge associated with comprehensive rehabilitation consistent with the European studies [3], which showed improvements in the same outcomes with more comprehensive rehabilitation services.

While our two additional analyses supported robustness of observed differences in functional gains, the direct adjustment of confounders did not support a relative home discharge advantage. In the VA, rehabilitation services assist in discharge planning. In an integrated healthcare system such as the VA, similar home discharge likelihood coupled with higher functional gains among those receiving comprehensive compared with consultative rehabilitation would be expected if discharge planning is operating optimally. Such a pattern could indicate that PM&R teams are appropriately selecting those patients for more intensive services who, due to limited caregiver support or lack of accessibility features, need to achieve higher degrees of independence in order to be discharged home.

Unlike the VHA, comprehensive rehabilitation in the private sector is typically provided after discharge from the acute hospitalization and is generally considered PAC. Nevertheless, PAC research shows improved functional recovery with admission to a specialized IRF over less intensive subacute or skilled nursing facilities [43,45–49].

As in our study, literature support of more comprehensive rehabilitation services improving home discharge likelihood over consultative services is not consistent. While the majority of studies document relative benefits in VAMCs [50] and private sector facilities [48–49], comprehensive rehabilitation in an IRF compared with a subacute rehabilitation unit in one study was associated with similar proportions of people being discharged to the community [45]. Home discharge can be influenced by factors outside the direct control of hospitalists, such as home accessibility and the availability of caregivers.

This study has a number of limitations. Potentially unmeasured confounding related to real world selection of comprehensive rehabilitation could be inflating the treatment-related outcome differences shown. Nevertheless, consistency of findings across our large observational study with the European studies [3] support the effectiveness of real-world comprehensive rehabilitation services for stroke. Because the VHA populations are primarily male and because of structural differences in the provision of rehabilitation, we cannot be certain that findings will generalize to rehabilitation services provided to the larger U.S. population.

CONCLUSIONS

These findings have implications to the care of patients with stroke in both the VHA and Medicare-reimbursed settings. Movement to bundled payments appears to be accelerating in response to passage of the Patient Protection and Affordable Care Act in 2010 [47]. The "minimal essential coverage" for tens of millions of patients in Medicare will include entitlement for rehabilitation services. Details about what constitutes "rehabilitation" are unclear. Cost containment efforts by necessity will move toward less comprehensive rehabilitation. It is thus essential to identify those conditions where comparative evidence supports comprehensive rehabilitation. Evidence is growing for stroke. As for effective models of care, it is noteworthy that VHA and Canadian best practice standards for stroke recognize the importance of standard functional assessment and rehabilitative potential evaluation early during hospitalization [51–52].

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