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Comparison of Risk Factor Control in the Year After Discharge for Ischemic Stroke Versus Acute Myocardial Infarction

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Background and Purpose—The Veterans Health Administration has engaged in quality improvement to improve vascular risk factor control. We sought to examine blood pressure (<140/90 mm Hg), lipid (LDL [low-density lipoprotein] cholesterol <100 mg/dL), and glycemic control (hemoglobin A1c <9%), in the year post-hospitalization for acute ischemic stroke or acute myocardial infarction (AMI).

Methods—We identified patients who were hospitalized (fiscal year 2011) with ischemic stroke, AMI, congestive heart failure, transient ischemic attack, or pneumonia/chronic obstructive pulmonary disease. The primary analysis compared risk factor control after incident ischemic stroke versus AMI. Facilities were included if they cared for ≥25 ischemic stroke and ≥25 AMI patients. A generalized linear mixed model including patient- and facility-level covariates compared risk factor control across diagnoses.

Results—Forty thousand two hundred thirty patients were hospitalized (n=75 facilities): 2127 with incident ischemic stroke and 4169 with incident AMI. Fewer stroke patients achieved blood pressure control than AMI patients (64%; 95% confidence interval, 0.62–0.67 versus 77%; 95% confidence interval, 0.75–0.78; $P<0.0001$). After adjusting for patient and facility covariates, the odds of blood pressure control were still higher for AMI than ischemic stroke patients (odds ratio, 1.39; 95% confidence interval, 1.21–1.51). There were no statistical differences for AMI versus stroke patients in hyperlipidemia ($P=0.534$). Among patients with diabetes mellitus, the odds of glycemic control were lower for AMI than ischemic stroke patients (odds ratio, 0.72; 95% confidence interval, 0.54–0.96).

Conclusions—Given that hypertension control is a cornerstone of stroke prevention, interventions to improve poststroke hypertension management are needed. **(*Stroke*. 2018;49:296-303. DOI: 10.1161/STROKEAHA.117.017142.)**

Key Words: diabetes mellitus ■ hyperlipidemia ■ hypertension ■ myocardial infarction ■ risk factors

The US Veterans Health Administration (VHA) engaged in quality improvement targeting vascular risk factors including hypertension, hyperlipidemia, and diabetes mellitus.[1] As a result, vascular risk factor control has improved in VHA hospitals.[2] Data from 2012 demonstrated that the average VHA facility pass rate was 78.5% for achieving a blood pressure (BP) of <140/90 mm Hg.[2]

In contrast to high levels of current performance, a study of the VHA from a decade ago evaluated BP and LDL (low-density lipoprotein) cholesterol after carotid endarterectomy, coronary artery bypass grafting, and percutaneous coronary intervention[3] finding that cerebrovascular disease patients were less likely to achieve control than cardiovascular disease patients. Specifically, the proportion of patients undergoing carotid endarterectomy with optimal control of both BP and LDL cholesterol increased from 23% to 33% after the procedure compared with increases from 32% to 43% for coronary artery bypass grafting and 29% to 45% for percutaneous coronary intervention.

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On the basis of these prior data from the VHA[3] and similar data from non-VHA settings,[4,5] we conducted the present study to compare the quality of BP control, lipid control, and glycemic control in the 1 year after an index hospitalization for ischemic stroke versus acute myocardial infarction (AMI) and examine postevent outpatient utilization for patients with ischemic stroke versus AMI. In secondary analysis, we examined the quality of risk factor control among patients with hospitalization for transient ischemic attack (TIA), congestive heart failure (CHF), and pneumonia/chronic obstructive pulmonary disease (COPD) exacerbation.

Methods

Design and Data

We identified patients with a hospitalization in fiscal year 2011 at a VHA facility for 1 of 5 conditions: AMI, ischemic stroke, TIA, CHF, or pneumonia/COPD exacerbation. We chose these diagnoses because they are clinically important, common, and represent 3 distinct categories: cerebrovascular events (stroke and TIA), cardiovascular events (AMI and CHF), and nonvascular events (pneumonia/COPD exacerbation). We collected VHA data on risk factor control and healthcare utilization during the 1-year preindex event and the 1 year post-discharge. We used VHA data sets for demographic data and *International Classification of Diseases*, Ninth Revision, (Clinical Modification) diagnostic and procedure information to identify inpatient and outpatient encounters. We collected laboratory, vital signs, and outpatient clinic visit data from the VHA Corporate Data Warehouse. We obtained dates of death from VA vital status files. We received human subjects and VHA Research and Development committee approvals. The data that support the findings of this study are stored on VHA servers; investigators interested in using the data described in these analyses should contact the corresponding author.

Population

Patients with a discharge diagnosis code (Table I in the online-only Data Supplement) from any VHA facility for ischemic stroke, TIA, AMI, CHF, or pneumonia/COPD exacerbation were included. The first admission (fiscal year 2011) was identified as the index hospitalization. Patients who were admitted to a non-VHA facility for their index hospitalization were not included. Patients were classified as either primary or secondary based on the primary or secondary discharge diagnosis, respectively. Patients with ischemic stroke and AMI were further classified as having either an incident (new) or a recurrent event based. Incident events were identified for patients without any inpatient or outpatient codes for that specific diagnosis in the previous 5 fiscal years. The primary analysis focused on patients with an incident ischemic stroke based on a primary diagnosis and patients with an incident AMI based on a primary diagnosis. A distinct category labeled vascular combination included patients with hospitalizations for ischemic stroke or TIA, and AMI or CHF. Patients were excluded if they died within the first 90 days post-discharge because our focus was posthospitalization vascular risk factor control and patients who died early post-discharge had limited opportunity for risk factor management. Facilities were included if they cared for ≥25 patients with incident ischemic stroke and ≥25 patients with incident AMI. Because the initial focus of our analysis was the evaluation of quality of care at the facility level, low-volume sites were excluded using methods similar to other studies of facility-level quality; the inherent uncertainty in observed rates because of small sample size can impair the comparisons across facilities.[6,7]

Outpatient Clinics

Using the methods used in VHA quality assessments, we identified outpatient visits where vascular risk factor management is likely to occur (Table I in the online-only Data Supplement).[8] We classified the clinics as primary care (primary care, general internal medicine, geriatrics, geriatrics primary care, and women's clinic); cardiology; and neurology or other specialty care (endocrine, diabetes mellitus, hypertension, infectious disease, pulmonary/chest, and renal/nephrology). Patients were assigned to the facility where they had the majority of their clinic visits in the 1 year post-discharge.[8] If there was an equal number of postdischarge clinic visits at ≥2 facilities or if there were no clinic visits, the patient was assigned to their index hospitalization facility. No minimum or maximum delay from discharge to the last clinic visit was imposed; all observed, eligible clinic visit data were used.

Vascular Risk Factor Control Outcomes

Facility risk factor control was estimated as the proportion of patients with target control level for each individual risk factor in the year post-hospitalization (pass rate). The use of electronic health record data for the assessment of vascular risk factor control has been evaluated in prior studies finding excellent agreement between electronic health record data and chart review.[9,10]

Hypertension

For the hypertension assessment, all patients were included as eligible. BP measurements taken at any eligible clinic (described above) were included; measurements taken in an Emergency Department, inpatient setting, or other outpatient clinics (eg, podiatry) were excluded. If multiple BP values were present on 1 day, we used the lowest value for that date. The average of all BP measurements for each patient was calculated in the 1 year post-discharge; no minimum or maximum number of BP measurements was required for this calculation. Passing was defined as an average systolic BP <140 mm Hg and an average diastolic BP <90 mm Hg.

Hyperlipidemia

All patients were considered eligible for lipid control; patients with the last LDL cholesterol <100 mg/dL in the 1-year postdischarge period were classified as passing.

Diabetes Mellitus

Patients with diabetes mellitus were eligible for glycemic control. After the standard used for the VHA performance measure for diabetes mellitus control, patients with an hemoglobin A1c (HbA1c) <9%[11] (based on the last measurement available) were classified as passing.

Covariates

Baseline characteristics at the time of index hospitalization included age, sex, and comorbidities. Diagnostic codes from 5 fiscal years before the index hospitalization, from both the inpatient and outpatient settings, were used to identify patient comorbidities. Comorbidities included the 5 conditions that defined the index hospitalization and diabetes mellitus, hypertension, or hyperlipidemia. A comorbidity was considered present on the basis of 1 inpatient code or 2 outpatient codes.[12] The Charlson comorbidity index was calculated.[13]

Analyses

The primary patient-level analysis evaluated the difference in vascular risk factor control between patients with incident AMI versus incident ischemic stroke; statistical comparisons in patient characteristics between these 2 groups were conducted using 2-sided independent *t* tests and χ^2 tests.

A generalized linear mixed model (GLMM) including patient- and facility-level covariates was used to compare all diagnoses on each of the 3 risk factor control outcomes.[14] Patient covariates included sex, age, Charlson comorbidity, history of diabetes mellitus (except in model for glycemic control), history of hyperlipidemia, history of hypertension, and number of clinic visits by type (eg, primary care, cardiology, neurology), and risk factor control before index event (mean systolic BP, last LDL cholesterol, or last HbA1c). Facility-level covariates included primary care quality[2] and geographic region (Caribbean, Midwest, Northeast, South, and West). A random facility

effect was included to account for correlation of patients from the same facility. The intraclass correlation (ICC) of each risk factor was estimated from a model which included only the facility-level random intercept. The ICC from the final model including all patient- and facility-level covariates was also estimated, and the percent of variability in facility-level risk factor control explained by the patient- and facility-level covariates was reported.

Multiple imputation, with 10 imputations (predictive mean matching method, SAS Proc MI), was used to impute the mean systolic BP for the BP model, the last LDL cholesterol value for the lipid model, and the last HbA1c value for the diabetes mellitus model. For example, the mean systolic BP was imputed by randomly selecting 1 of the 5 observed values whose predicted values were closest to the predicted value for the missing value from the simulated regression model. The GLMM was fit to each of the 10 imputed data sets for each outcome. The population-adjusted risk factor control and 95% confidence intervals (CIs) for all diagnostic groups and the odds ratios (ORs) and associated 95% CIs were estimated by combining the model results which takes into account the additional uncertainty because of the imputation.[15] ORs were estimated with continuous covariates set at their mean.

The focus of the analysis was initially at the facility level. Therefore, we began the primary analyses by visually comparing differences in risk factor control across facilities between diagnoses. These figures were used to determine whether disparities in care between ischemic stroke and AMI patients were more evident at facilities providing suboptimal care. Facilities were sorted by the pass rates for the incident AMI population in ascending order (increased quality of care over the *x* axis). The observed proportion of patients who passed the measure at each facility was plotted along with a 95% exact (Clopper–Pearson) confidence interval (CI). For the ischemic stroke population, the facilities were placed in the order defined by the AMI population, and the proportion of patients with incident ischemic stroke who passed the measure was similarly plotted with the 95% CIs. In addition, we included horizontal lines to represent the overall mean and 95% CIs for the measure across facilities. For each figure, medical centers were arbitrarily labeled; thus, sites cannot be compared across figures.

Sensitivity Analyses

We conducted 3 sensitivity analyses to evaluate the BP control results. To examine the impact of missing data on the estimation of the ORs, we imputed the BP outcome with fully conditional specification logistic regression in addition to the predictive mean matching imputation used for the covariate of mean systolic BP before index event. To verify that the difference in hypertension control between ischemic stroke and AMI patients was not dependent on whether the patient was cared at an ischemic stroke-serving facility, we created an indicator for facilities serving >50 ischemic stroke patients per year. We then built a GLMM for hypertension control including a random facility effect and additional fixed effects for diagnostic group, stroke serving (yes/no), and the 2-way interactions. To assess whether the disparity in BP control (ischemic stroke versus AMI) might be partially because of how patients were classified into diagnostic categories, we reran the primary model and reported the ORs from the new model with ischemic stroke patients placed in the vascular combination group.

Results

Fifty-five thousand four hundred thirteen patients were hospitalized for 1 of the 5 diagnoses at 130 facilities. Seven thousand four hundred ninety-three patients died within 90 days after the index hospitalization. Another 7690 patients were excluded because they were hospitalized at the 55 facilities with <25 ischemic stroke and AMI patients (Figure I in the online-only Data Supplement). Our analytic cohort included 40 230 patients who received care at 75 facilities (Table 1). Among 4141 ischemic stroke patients, 2127 had an incident stroke. Among 9575 AMI patients, 4169 had an incident AMI.

Table 1. Final Diagnostic Classification

Diagnostic Classification	n=40 230 Patients 75 Facilities (%)
Primary analysis	
Incident stroke	2127 (5.3)
Incident AMI	4169 (10.4)
Secondary analysis	
Secondary diagnosis incident or recurrent ischemic stroke	2014 (5.0)
Secondary diagnosis incident or recurrent AMI	5406 (13.4)
CHF	11 265 (28.0)
TIA	1233 (3.1)
Chronic obstructive pulmonary disease or pneumonia	7579 (18.8)
Vascular combination (stroke/TIA and AMI/CHF)	6437 (16.0)
Total	40 230 (100)

AMI indicates acute myocardial infarction; CHF, congestive heart failure; TIA, transient ischemic attack.

Patients with incident ischemic stroke were older (mean±SD, 67.3±10.8 years versus 65.7±11.1 years; $P<0.0001$), were less likely to have a history of hypertension (70.6% versus 74.6%; $P<0.001$), hyperlipidemia (54.3% versus 68.9%; $P<0.0001$), and diabetes mellitus (34.3% versus 38.6%; $P=0.001$) compared with incident AMI patients (Table 2).

Hypertension

Incident AMI patients had more BP measurements in the 1 year post-discharge than incident ischemic stroke patients: mean number of BP measurements, 5.6 (range, 0–197; median, 5.0; interquartile range, 4.0; SD, 5.3) versus 4.7 (range, 0–154; median, 4.0; interquartile range, 4.0; SD, 5.3; $P<0.0001$).

From the GLMM with patient-level BP control as the outcome and a random facility intercept term only, the ICC was estimated to be 0.013 (random intercept=0.044). From the

Table 2. Patient Characteristics

Characteristic	Incident Ischemic Stroke (n=2127)	Incident Acute Myocardial Infarction (n=4169)	*P* Value*
Age, y, mean±SD	67.3±10.8	65.7±11.1	<0.0001
Charlson comorbidity index, mean±SD	0.3±0.9	0.4±0.9	<0.0001
Male, n (%)	2064 (97.0)	4064 (97.5)	0.302
Hypertension, n (%)	1501 (70.6)	3110 (74.6)	<0.001
Hyperlipidemia, n (%)	1156 (54.3)	2873 (68.9)	<0.0001
Diabetes mellitus, n (%)	730 (34.3)	1607 (38.6)	0.001

*The *P* value was obtained from *t* tests for continuous variables and χ^2 tests for categorical variables.

Table 3. Multivariable Model (GLMM) for Vascular Risk Factor Control

	Hypertension Control*; n=37 188 Patients		LDL Cholesterol Control†; n=31 367 Patients		Glycemic Control‡; n=15 978 Patients	
Covariates	OR (95% CI)	*P* Value	OR (95% CI)	*P* Value	OR (95% CI)	*P* Value
Patient level						
Primary analysis (reference: incident stroke)						
Incident AMI	1.39 (1.21–1.59)	<0.0001	1.05 (0.91–1.21)	0.534	0.72 (0.54–0.96)	0.028
Secondary analysis						
Secondary incident or recurrent AMI	1.52 (1.33–1.74)	<0.0001	0.83 (0.72–0.96)	0.011	0.59 (0.45–0.78)	0.0002
Secondary incident or recurrent stroke	1.14 (0.98–1.33)	0.109	0.72 (0.61–0.85)	0.0002	1.00 (0.71–1.42)	>0.999
TIA	1.09 (0.91–1.3)	0.352	0.59 (0.49–0.71)	<0.0001	0.90 (0.59–1.37)	0.631
CHF	1.48 (1.31–1.67)	<0.0001	0.67 (0.59–0.77)	<0.0001	0.65 (0.50–0.84)	0.001
COPD/pneumonia	1.31 (1.16–1.48)	<0.0001	0.46 (0.40–0.53)	<0.0001	0.96 (0.72–1.28)	0.762
Vascular combination	1.26 (1.11–1.43)	0.0004	0.79 (0.69–0.91)	0.0009	0.75 (0.57–0.98)	0.036
Age	1.01 (1.01–1.01)	<0.0001	1.02 (1.02–1.02)	<0.0001	1.03 (1.02–1.04)	<0.0001
Female sex	1.18 (1.01–1.38)	0.046	0.70 (0.60–0.81)	<0.0001	1.12 (0.83–1.52)	0.458
Charlson comorbidity index	1.00 (0.99–1.01)	0.482	1.01 (0.99–1.03)	0.181	1.01 (0.99–1.03)	0.228
History of diabetes mellitus	0.90 (0.85–0.95)	0.0003	1.35 (1.27–1.44)	<0.0001	…	
History of hypertension	0.58 (0.53–0.63)	<0.0001	1.20 (1.11–1.30)	<0.0001	1.16 (0.94–1.44)	0.181
History of hyperlipidemia	1.21 (1.13–1.29)	<0.0001	0.79 (0.74–0.85)	<0.0001	0.81 (0.69–0.95)	0.009
Risk factor control in the year before the index event	Mean BP systolic (5 points); 0.73 (0.72–0.74)	<0.0001	Last LDL (10 points); 0.81 (0.80–0.82)	<0.0001	Last A1c (1 point); 0.57 (0.55–0.59)	<0.0001
No. of primary visits (year post-event)	1.00 (0.99–1.01)	0.304	1.00 (0.99–1.01)	0.316	0.99 (0.98–1.00)	0.056
No. of cardiology visits (year post-event)	1.07 (1.06–1.08)	<0.0001	1.04 (1.03–1.05)	<0.0001	1.01 (0.99–1.03)	0.107
No. of neurology/other visits (year post-event)	0.98 (0.97–0.99)	0.002	1.02 (1.01–1.03)	0.005	0.98 (0.96–1.00)	0.005
Facility level (75 facilities)						
Primary care vascular risk factor control (0.10 U change)§	1.16 (0.98–1.38)	0.101	1.29 (1.09–1.53)	0.003	1.36 (1.11–1.67)	0.003
VAMC region (reference: West)						
Caribbean	1.33 (0.94–1.89)	0.117	1.14 (0.82–1.59)	0.436	0.81 (0.58–1.12)	0.210
Midwest	0.92 (0.81–1.05)	0.213	0.99 (0.87–1.13)	0.875	0.99 (0.85–1.16)	0.914
Northeast	0.98 (0.83–1.16)	0.856	0.98 (0.83–1.16)	0.804	0.96 (0.79–1.17)	0.666
South	0.93 (0.83–1.04)	0.215	0.99 (0.89–1.10)	0.919	1.00 (0.87–1.14)	0.979
Random facility intercept (σ^2_F)	0.019 (SE=0.0063)	0.002	0.016 (SE=0.0054)	0.002	…	…
Random intercept/(random intercept+π^2/3)	ICC=0.006	…	ICC=0.005	…	…	…

AMI indicates acute myocardial infarction; BP, blood pressure; CHF, congestive heart failure; CI, confidence interval; COPD, chronic obstructive pulmonary disease; GLMM, generalized linear mixed model; ICC, intraclass correlation; LDL, low-density cholesterol; OR, odds ratio; TIA, transient ischemic attack; VAMC, Department of Veterans Affairs Medical Center; and VHA, Veterans Health Administration.

*The hypertension control model results were reported with covariates set at means: facility-level risk control, 0.7744; age, 68.7, Charlson, 1.266; primary visits, 5.231; cardiology visits, 1.702; neuro/other visits, 1.476; and mean BP systolic year prior, 132.03. Multiple imputation was used for the mean systolic blood pressure in the year before the index event.

†The lipid control model results were reported with covariates set at means: facility-level risk control, 0.775; age, 68.4, Charlson, 1.274; primary visits, 5.387; cardiology visits, 1.805; neuro/other visits, 1.517; and last LDL, 90.36. Multiple imputation was used for the last LDL cholesterol before the index event.

‡The glycemic control model results were reported with covariates set at means: facility-level risk control, 0.775; age, 68.9, Charlson, 1.836; primary visits, 5.387; cardiology visits, 1.805; neuro/other visits, 1.517; and last HbA1c, 7.47%. The random intercept term was removed (<0.0003). Multiple imputation was used for the last HbA1c before the index event.

§The facility primary care vascular risk factor control was based on a composite measure from VHA External Peer Review Program.[2]

fully-adjusted model, the ICC was reduced to 0.006 (random intercept=0.019). Therefore, ≈57% (0.025/0.044) of the variability in facility-level BP control was explained by the patient- and facility-level covariates. Mean systolic BP before index event was imputed for 7% of patients (2602/37 188) using multiple imputation. From the GLMM, the odds of achieving BP control were higher for incident AMI than for incident ischemic stroke patients (OR, 1.39; 95% CI, 1.21–1.59) after adjusting for patient- and facility-level covariates (Table 3). Comparisons of adjusted-mean BP control demonstrated that the best BP control (red line, Figure) was among patients with a secondary new or recurrent AMI (0.86; 95% CI, 0.85–0.88) and the worst (green line, Figure) was for incident ischemic stroke patients (0.81; 95% CI, 0.78–0.83). Overall, patients with recurrent/secondary incident AMI, CHF, incident AMI, and COPD/pneumonia were similar with regard to BP control and were at the better end of the spectrum, whereas patients with recurrent/secondary incident ischemic stroke, TIA, and incident ischemic stroke were at the worse end of the spectrum (Figure).

From the GLMM model that included the random facility-level intercept only, the mean pass rate for BP control for incident ischemic stroke was 64.4% (95% CI, 62.0%–66.8%) versus 76.7% for incident AMI (95% CI, 75.1%–78.3%; Table 4). In the fully-adjusted analysis, the mean BP control pass rates were also lower for the incident ischemic stroke patients, 80.6% (95% CI, 78.1%–82.9%), compared with the incident AMI patients, 85.3% (95% CI, 83.4%–86.9%; Table 4). At 65 of 75 facilities (87%), the proportion of AMI patients with BP control was greater than the proportion of stroke patients with BP control (Figure II in the online-only Data Supplement). A relatively stable difference between ischemic stroke versus AMI pass rates was observed across the spectrum of facilities from lower performing (Figures II through IV, left, in the online-only Data Supplement) to higher performing sites (Figures II through IV, right, in the online-only Data Supplement) across each of the 3 risk factors.

Results of sensitivity analyses (Table II in the online-only Data Supplement) provide evidence that the difference in BP control for incident ischemic stroke versus incident AMI patients was not influenced by missing BP values, whether the ischemic stroke and TIA patients were categorized with the incident stroke group or vascular combination groups, or whether patients were cared for at stroke-serving facilities.

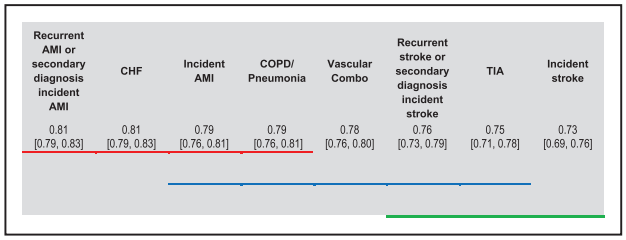

Figure. The diagnostic categories are listed from the highest blood pressure (BP) control on the left to the lowest on the right. Estimations were obtained from generalized linear mixed model (GLMM) using multiple imputation methods. Hypertension control for diagnostic groups connected by lines is not significantly different after adjusting for multiple comparisons with Sidak adjustment. AMI indicates acute myocardial infarction; CHF, congestive heart failure; COPD, chronic obstructive pulmonary disease; and TIA, transient ischemic attack.

Hyperlipidemia

From the GLMM with patient-level lipid control as the outcome and a random facility intercept term only, the ICC was estimated to be 0.012 (random intercept=0.041). From the fully-adjusted model, the ICC was reduced to 0.005. Thus, ≈61% of the variability in facility-level lipid control was explained by the patient and facility-level covariates. The last LDL before index event was imputed for 13.9% of patients (4354/31 367). The odds of achieving LDL cholesterol control were similar for incident AMI and incident ischemic stroke patients (OR, 1.05; 95% CI, 0.91–1.21) after adjusting for patient- and facility-level covariates (Table 3). Patients from all other diagnostic categories had worse LDL cholesterol control than incident ischemic stroke patients (Table 3).

No differences in observed facility-level hyperlipidemia control for incident ischemic stroke versus incident AMI patients were observed (Figure III in the online-only Data Supplement). Hyperlipidemia control rates were lowest among patients with pneumonia/COPD exacerbation (Table 4). A key finding was that 468 of 2127 (22.0%) of the new ischemic stroke patients had no LDL measurement 1 year post-discharge compared with 528 of 4169 (12.7%) of new AMI patients without an LDL measurement ($P<0.0001$; Table III in the online-only Data Supplement).

Diabetes Mellitus

The facility ICC for HbA1c control was 0.005. However, after adjusting for patient- and facility-level covariates, the random intercept term was found to be negligible and removed from the model. The last HbA1c before index event was imputed for 5% of patients (796/15 978) using multiple imputation. The odds of achieving HbA1c control were lower for incident AMI patients compared with incident ischemic stroke patients (OR, 0.72; 95% CI, 0.54–0.96) after adjusting for patient- and facility-level covariates (Table 3).

Overall, observed facility-level glycemic control was similar for incident ischemic stroke patients and incident AMI patients (Figure IV in the online-only Data Supplement). Across the 5 diseases, the adjusted diabetes mellitus pass rates were relatively similar, but the lowest rate was for secondary incident/recurrent AMI and the highest rate was for incident stroke (Table 4). Missing HbA1c values post-discharge were more common among incident ischemic stroke patients (90/730 [12.3%]) than incident AMI patients (153/1607 [9.5%]; $P=0.039$; Table III in the online-only Data Supplement).

Healthcare Utilization

Overall, 6% (n=2429) of patients did not have a clinic visit within the 1-year postindex hospitalization period. The mean time from hospital discharge to the last clinic visit for incident AMI patients was 282.5 days (range, 1–365 days; median, 313.0 days; interquartile range, 101.0 days; SD, 84.8 days) and was 268.5 days for patients with incident ischemic stroke (range, 4–365 days; median, 300.0 days; interquartile range, 115.0 days; SD, 92.3 days).

Incident AMI patients had more outpatient visits than incident stroke patients both pre- and post-hospitalization: mean of 4.9±4.8 visits (median 4) 1 year pre-hospitalization versus

Table 4. Vascular Risk Factor Control for Patients After Ischemic Stroke and Myocardial Infarction (n=75 Facilities)

	Partially Adjusted†		Fully Adjusted‡	
Diagnostic Category*	Mean	95% CI	Mean	95% CI
Blood pressure control (n=37 188 patients)				
Incident AMI	0.767	(0.751–0.783)	0.853	(0.834–0.869)
Incident stroke	0.644	(0.620–0.668)	0.806	(0.781–0.829)
Secondary incident/recurrent AMI	0.804	(0.790–0.817)	0.863	(0.846–0.879)
Secondary incident/recurrent stroke	0.706	(0.681–0.729)	0.825	(0.801–0.847)
TIA	0.723	(0.695–0.750)	0.819	(0.791–0.844)
CHF	0.789	(0.777–0.800)	0.861	(0.845–0.875)
COPD/pneumonia	0.777	(0.764–0.790)	0.844	(0.827–0.86)
Vascular combination	0.747	(0.733–0.762)	0.840	(0.821–0.857)
LDL cholesterol control (n=31 367 patients)				
Incident AMI	0.751	(0.734–0.767)	0.810	(0.788–0.829)
Incident stroke	0.723	(0.699–0.745)	0.802	(0.776–0.826)
Secondary incident/recurrent AMI	0.803	(0.789–0.816)	0.770	(0.746–0.793)
Secondary incident/recurrent stroke	0.718	(0.693–0.742)	0.746	(0.715–0.775)
TIA	0.652	(0.62–0.683)	0.704	(0.667–0.739)
CHF	0.768	(0.756–0.78)	0.732	(0.708–0.754)
COPD/pneumonia	0.616	(0.599–0.633)	0.650	(0.622–0.676)
Vascular combination	0.786	(0.772–0.799)	0.762	(0.738–0.784)
HbA1c control (n=15 978 patients)				
Incident AMI	0.835	(0.815–0.854)	0.891	(0.865–0.913)
Incident stroke	0.836	(0.805–0.863)	0.919	(0.893–0.939)
Secondary incident/recurrent AMI	0.826	(0.810–0.840)	0.870	(0.843–0.893)
Secondary incident/recurrent stroke	0.875	(0.848–0.897)	0.919	(0.892–0.940)
TIA	0.885	(0.849–0.913)	0.911	(0.875–0.937)
CHF	0.852	(0.841–0.863)	0.881	(0.857–0.901)
COPD/pneumonia	0.888	(0.872–0.902)	0.915	(0.895–0.932)
Vascular combination	0.855	(0.842–0.868)	0.895	(0.872–0.914)

AMI indicates acute myocardial infarction; CHF, congestive heart failure; CI, confidence interval; COPD, chronic obstructive pulmonary disease; LDL, low-density cholesterol; and TIA, transient ischemic attack.

*The vascular combination category includes patients with hospitalizations for stroke, TIA, AMI, or CHF.

†Partially-adjusted means were obtained from generalized linear mixed model (GLMM) including only diagnostic category and random facility-level intercept.

‡Fully-adjusted means were obtained from the results of 10 imputations with GLMM and included patient/facility-level covariates and random facility intercept.

mean of 3.9±3.8 visits (median 3; $P<0.0001$). Similarly, incident AMI patients had a mean of 7.9±6.1 visits (median 7) post-discharge, whereas incident stroke patients had a mean of 6.0±4.5 visits (median 5) post-discharge ($P<0.0001$). The primary difference in postdischarge outpatient utilization was increased cardiology visits for AMI patients (2.5 cardiology visits per patient versus 0.4 visits per patient; $P<0.0001$; Table 5). On the basis of the adjusted GLMM models, cardiology visits were associated with improved BP control (OR, 1.07; 95% CI, 1.06–1.08), primary care visits were not associated with BP control (OR, 1.00; 95% CI, 0.99–1.01), and neurology clinic visits were associated with worse BP control (OR, 0.98; 95% CI, 0.97–0.99; Table 3). A similar pattern was observed for glycemic control (Table 3). In contrast, both cardiology visits and neurology visits were associated with improved LDL cholesterol control (Table 3).

Pre-Event Hypertension Control

Secondary analyses were conducted to explore possible causes of the observed differences in hypertension control. Incident stroke patients (n=1725) had higher mean BP values before their index event compared with incident AMI patients (n=3662): 139.7/79.1 (±17.5/11.8) mm Hg versus 134.6/76.5 (±15.1/10.7) mm Hg (*t* test $P<0.0001$ for diastolic blood pressure and SBP).

Table 5. Outpatient Visits in Year After Hospitalization for Ischemic Stroke or Acute Myocardial Infarction

	Incident Acute Myocardial Infarction (n=4169)			Incident Ischemic Stroke (n=2127)		
Clinic	No. of Visits	Proportion of Visits	Mean Per Patient±SD	No. of Visits	Proportion of Visits	Mean Per Patient±SD
Primary care	19216	58.6%	4.6±3.9	9077	71.2%	4.3±3.4
Cardiology	10281	31.4%	2.5±3.5	889	7.0%	0.4±1.0
Neurology	510	1.6%	0.1±0.5	1786	14.0%	0.8±1.1
Other	2766	8.4%	0.7±1.7	995	7.8%	0.5±1.4
Total	32773	100%	7.9±6.1; Range: 0.0–58.0; Median: 7.0; IQR: 6.0	12747	100%	6.0±4.5; Range: 0.0–37.0; Median: 5.0; IQR: 5.0

IQR refers to the interquartile range.

Stroke patients similarly had higher BP values after the index event: 134.2/76.8 (±15.1/10.0) mm Hg versus 128.7/73.4 (±14.4/9.8) mm Hg (P<0.0001 for diastolic blood pressure and SBP). Stroke patients versus AMI patients were more likely to have both worsening of control (pass pre-event and fail post-event: 10.1% versus 8.2%; P<0.0001) and improving control (fail pre-event and pass post-event: 23.7% versus 20.8%; P<0.0001; Table IV in the online-only Data Supplement). The relative disparity in observed hypertension control for AMI patients compared with ischemic stroke patients before the index event (63.9%−51.2%=12.7%) was similar to the relative disparity after the index event (76.6%−63.9%=12.6%).

Discussion

These results demonstrate that hypertension control is worse for patients with cerebrovascular disease than cardiovascular disease, although gaps in care exist for both populations. When comparing our results to prior reports from the VHA,[3] Canada,[4] and France,[5] 3 key findings are apparent: risk factor control has improved considerably over time; risk factor control improves after hospitalization compared with preindex event hospitalization; and although disparities in BP control continue to be present between ischemic stroke and AMI patients, lipid control rates were similar for stroke and AMI patients and diabetes mellitus control rates were lower for AMI than ischemic stroke patients.

One hypothesis for why cerebrovascular disease patients may have worse hypertension control compared with cardiovascular patients is that cardiologists caring for the latter are comfortable with hypertension management, whereas neurologist may not be comfortable titrating medications and primary care providers may wait for instructions from neurology. Uncontrolled BP has been demonstrated in one third to half of poststroke patients[8,16,17] and poststroke clinical inertia exists such that treatment intensification does not occur at least 35% of visits with elevated BPs among poststroke patients.[8] Stroke patients are more likely to receive monotherapy for hypertension than AMI patients.[5] Future studies should assess whether lack of care coordination, discomfort with risk factor modification by neurologists, or fear of overtreating hypertension by primary care providers may contribute to inadequate BP control poststroke.

Another potential explanation for our results is that stroke patients have more severe hypertension than patients with other diseases. The observation that stroke patients had higher BP pre-hospitalization provides support for this hypothesis. Given the absence of pharmacy data, we cannot assess the degree to which ischemic stroke patients' pre-event hypertension was because of disease severity, reduced medication adherence, or undertreatment. Prior research suggests that both poor adherence and undertreatment exist poststroke[8]; however, the degree to which these vary for AMI versus ischemic stroke patients is unknown.

It may also be that post-AMI patients routinely receive β-blockers which lower BP, and, therefore, post-AMI patients are more likely than poststroke patients to achieve BP control.[1] Because we did not have medication data, we could not examine whether differences in antihypertensives may contribute to disparities in postevent BP control.

Risk factor control rates for patients with CHF and the vascular combination were similar to rates for AMI patients, suggesting that care by cardiologists may be a shared mechanism for risk factor management. Control for patients with pneumonia/COPD exacerbations varied across the risk factors. We expected that risk factor control for TIA would have been similar to ischemic stroke, but found that the TIA rates were higher than ischemic stroke rates for BP and lower than stroke for both lipid control and diabetes mellitus control.

The strengths of this study were its large sample size, national scope, and inclusion of a range of causes of index hospitalization. Limitations of this study included the lack of medication data which could have been used to assess disease severity, patient adherence, and provider behavior (inertia and medication management practices); the reliance on the VHA electronic health record data, which albeit robust for the assessment of laboratory data and vital signs[9,10,18] lacks the details of chart review data which might have provide insight into the judgment of clinicians; and the lack of stroke subtype information. This study evaluated care for Veterans in VHA hospitals; therefore, these results might not generalize to other healthcare settings or populations (ie, women). Given the observational cohort design of this study, the estimate of vascular risk factor control is based on available data and potential bias may be related to heterogeneity in measurements between groups. Our assessment of vascular risk factor quality depends on patients having BP, LDL cholesterol, and HbA1c measurements in the electronic health record data. For this reason, we examined the difference in healthcare utilization between incident AMI patients and incident ischemic stroke patients because observed differences in clinic visits (both frequency and timing) might provide insight into the

observed difference in vascular risk factor control in general and BP control, in particular. This study used single definitions of passing for each process of care; future studies should examine the degree to which the results might vary based on alternative definitions (eg, prescription of high/moderate potency statin versus an LDL cholesterol <100 mg/dL).

In conclusion, these results demonstrate clinically substantial disparities in hypertension control among patients with ischemic stroke versus patients with AMI. Given the observation that AMI patients receive more outpatient visits than ischemic stroke patients and that these additional visits are with cardiology, it may be that cardiologists provide risk factor management to the AMI patients that ischemic stroke patients do not receive. Because hypertension control is a cornerstone of stroke secondary prevention, interventions are needed which will improve hypertension management poststroke.

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Disclosures

None.

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