Original Paper

Antihypertensive Medication Prescribing Patterns in a University Teaching Hospital

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Treatment of hypertension among hospitalized patients represents an opportunity to improve blood pressure recognition and treatment. To address this issue, the authors examined patterns of antihypertensive medication prescribing among 5668 hypertensive inpatients. Outcomes were treatment with any antihypertensive medication and treatment with first-line therapy, defined as angiotensin-converting enzyme inhibitors, β-blockers, thiazide diuretics, or calcium channel blockers. Logistic regression models adjusting for age, sex, race, length of stay, service line, and comorbidity were used for all comparisons. The multivariate-adjusted odds ratios for treatment were higher for men (1.4, P<.001), older patients (2.5 for age older than 80 vs 1.0 for age younger than 40; P<.001), non-white race (1.2 vs 1.0 for white race; P<.004), and generalist service line (1.4 vs 1.0 for all other services; P<.001). Multivariate-adjusted odds ratios for receiving first-line agents were higher for older patients and generalist service line. Among surgical patients, receipt of medical consultation was only marginally associated with higher odds of

antihypertensive or first-line treatment after adjustment for relevant clinical variables. Demographic factors and service line appear to play a major role in determining the likelihood of inpatient hypertension treatment. Understanding and addressing these disparities has the potential to incrementally improve hypertension control rates in the population. J Clin Hypertens (Greenwich). 2010;12:246–252. ©2010 Wiley Periodicals, Inc.

Hypertension is a primary risk factor for cardiovascular disease, stroke, and death that affects approximately 70 million adults in the United States.[1,2] Despite decades of national educational efforts and published treatment guidelines, however, approximately 39 million Americans are not at their goal blood pressure (BP). Epidemiologic data from National Health and Nutrition Examination Survey (NHANES) reports indicate that younger hypertensive patients younger than 40 years and Hispanics are less likely to be treated for their hypertension. Furthermore, African Americans and women older than 60 years are less likely to achieve control when treated.[1,3] Providers often fail to recognize and intensify treatment regimens for uncontrolled hypertension, and nongeneralist providers typically perform more poorly than internists.[4,5] Novel strategies are needed to better identify and treat patients with hypertension who are previously undiagnosed or who are treated but not at their goal BP.

The vast majority of research on the detection and treatment of hypertension has appropriately focused on the outpatient setting, but available evidence suggests that elevated BP observed in

hospitalized patients likely represents hypertension.[6–8] Indeed, the prevalence of hypertension and cardiovascular risk factors among inpatients appears to be high, at over 50%.[9] In 2002, there were more than 38 million inpatient hospitalizations and roughly 33 million additional surgical procedures among adults.[10,11] Given the shortcomings of outpatient-based screening and treatment, better recognition of hypertension in the inpatient setting represents an opportunity to improve hypertension treatment and control.

A prior study by Jankowski and colleagues[12] offers insight into the potential impact of inpatient hypertension recognition and treatment. They studied inpatients admitted with ischemic heart disease and found that 17% of patients in this high-risk population who met criteria for hypertension did not receive a diagnosis at that time. Such patients were 4 times (19.2% vs 4.5%; $P<.0001$) more likely to be untreated for hypertension at 6 to 18 months post-discharge and less likely to be controlled at <140/90 mm Hg. Not surprisingly, treatment with a BP-lowering agent at discharge was associated with the lowest odds of nontreatment at follow-up (odds ratio [OR], 0.08; 95% confidence interval [CI], 0.3–0.19). Studies such as this one suggest that there is an opportunity to improve diagnosis and treatment rates for hypertensive patients by careful attention to elevated BP observed in the inpatient setting.

The goal of the present study was to describe the antihypertensive medication–prescribing patterns for inpatients with hypertension at a university teaching hospital in the United States in order to better understand the patterns of care for inpatients and potential opportunities for improvement in hypertension management.

MATERIALS AND METHODS

We conducted a cross-sectional study to examine patterns of prescribing for inpatients with a diagnosis of hypertension approved by the Office of Research Protection at the Medical University of South Carolina. Administrative data were used to identify a total of 5668 non–intensive care unit adult inpatients and a subset of 2323 surgical inpatients discharged during calendar year 2006 from an index hospitalization with a primary or secondary billing diagnosis of hypertension. Patients admitted to the intensive care unit and patients with primary or secondary diagnoses of hypotension, sepsis syndrome, and acute renal failure were excluded as patients who might appropriately have their antihypertensive medications withheld during hospitalization. Diagnostic and inpatient pharmacy records were combined with physician billing records to identify patients receiving hospitalist consultation.

Variables of interest were treatment with any antihypertensive medication and use of first-line medications, defined as a thiazide diuretic, angiotensin-converting enzyme (ACE) inhibitor, β-blocker (BB), or calcium channel blocker (CCB). Initially, descriptive statistics were calculated, followed by a series of chi-square tests to compare the group of patients treated with any antihypertensive with the group of untreated patients with respect to age, sex, race, length of stay (LOS), service line (internal medicine or family medicine vs all other services such as neurology, cardiology, and general surgery), and comorbidity.

We then created a series of multiple logistic regression models to adjust for known and potential confounders of relationship between having a hypertension diagnosis and receiving antihypertensive medications while hospitalized. In model 1 and model 3, the dependent variable was receipt of any antihypertensive medication. In model 2 and model 4, the dependent variable was receipt of first-line antihypertensive drug class. Antihypertensive medication administration was determined based on pharmacy-dispensing data by unique drug code. Independent variables included sociodemographic factors, provider factors, and clinical factors. Sociodemographic variables included age category (≤40 years, 41–60 years, 61–80 years, >80 years), sex, race/ethnicity (white vs other), and insurance type (private, Medicaid, Medicare, other). Hospital service line was included to adjust for provider type. Mean LOS and Charlson Comorbidity Index were included to adjust as additional patient factors. Each patient's Charlson Comorbidity Index score was calculated using all of his/her recorded International Classification of Diseases, 9th Edition (ICD-9) diagnosis codes.[13,14] In model 3 and model 4, the sample was restricted to patients cared for by surgical services such as general surgery, orthopedic surgery, neurosurgery, and others and an indicator variable for receipt of a general internal medicine or hospitalist consult was added to the models as a key predictor variable. All analyses were conducted using SAS version 9.2 (SAS Institute, Cary, NC).

RESULTS

This sample had a mean age of 60.2 years, was 50.1% female, 42% black, 57% white, and 55% had Medicare, with a median LOS of 4.2 days. Overall,

Table I. Summary of the Logistic Regression Model for All Hypertensive Inpatients Predicting Treatment With Any Antihypertensive Medication

Patient Characteristic	No.	Proportion Treated, %[a]	Odds Ratio	95% Confidence Interval	P Value
Age group, y					
≤40	524	68.5	1.0	Referent	–
41–60	2298	79.0	1.7	(1.4–2.2)	<.001
61–80	2410	83.4	2.1	(1.6–2.6)	<.001
>80	436	86.5	2.5	(1.7–3.6)	<.001
Female	2842	78.3	1.0	Referent	–
Male	2826	82.8	1.4	(1.2–1.6)	<.001
Race/ethnicity					
White	3212	79.6	1.0	Referent	–
Other	2456	81.7	1.2	(1.1–1.4)	.004
Insurance					
Private	1510	75.8	1.0	Referent	–
Medicaid	445	80.5	1.3	(1.0–1.6)	.46
Medicare	3127	73.8	1.3	(1.1–1.5)	.026
Other	586	75.1	0.9	(0.7–1.1)	.016
Length of stay, d					
<2	1433	81.2	1.0	Referent	–
2–4	2676	79.9	1.1	(0.9–1.3)	.51
>4	1559	80.9	1.1	(0.9–1.4)	.23
Surgical service	2922	77.3	1.0	Referent	–
Medical service	2746	83.9	1.4	(1.2–1.6)	<.001
Charlson Comorbidity Index					
0	1521	74.2	1.0	Referent	–
1	1448	81.6	1.4	(1.1–1.6)	.24
2	1156	84.5	1.5	(1.2–1.9)	.015
3	701	85.6	1.6	(1.2–2.0)	.016
4	345	86.4	1.5	(1.1–2.1)	.164
≥5	497	76.1	0.8	(0.6–1.0)	<.001

[a]Proportion of patients treated with any antihypertensive medication.

80.5% of patients were treated with any antihypertensive medication during their hospital stay. As depicted in Table I, the multivariate-adjusted ORs from model 1 for receipt of any antihypertensive medication while hospitalized significantly varied by age, sex, race/ethnicity, insurance type, service line, and comorbidity score. The OR for treatment significantly increased in each age category, with patients older than 80 years most likely to be treated (OR, 2.5; 95% CI, 1.7–3.6). Men were more likely to be treated than women (OR, 1.4; 95% CI, 1.2–1.6). Patients in other racial and ethnic groups were more likely to receive antihypertensive medications compared with whites (OR, 1.2; 95% CI, 1.1–1.4). Patients with Medicare insurance were more likely to be treated with antihypertensive medications than patients with private insurance (OR, 1.3; 95% CI, 1.1–1.5). Patients cared for by generalist physicians were more likely to be treated with antihypertensive medications compared with those cared for by providers from other service lines (OR, 1.4; 95% CI, 1.2–1.6). Finally, patients with mild to moderate comorbidity (Charlson score of 1–4) were more likely to receive antihypertensive therapy than patients without comorbidity (Charlson score of 0, referent) or patients with higher comorbidity (Charlson score ≥5).

The results for model 2 are depicted in Table II. Among treated patients the multivariate-adjusted odds of receiving first-line antihypertensive medications significantly varied by LOS, service line, and degree of comorbidity. Intermediate LOS of 2 to 4 days was associated with lower odds of receiving first-line agents (OR, 0.8; 95% CI, 0.6–1.0). Patients cared for by generalist physicians were more likely to be treated with first-line antihypertensive medications compared with those cared for by providers from other service lines (OR, 1.3; 95% CI, 1.1–1.6). Again, patients with intermediate comorbidity scores had higher odds of receiving first-line agents.

As depicted in Table III, results for model 3 for surgical patients indicate that increasing age, male

Table II. Summary of the Logistic Regression Model for all Hypertensive Inpatients Prescribed Any Antihypertensive Medication Predicting Treatment With a First-Line Antihypertensive Medication

PATIENT CHARACTERISTIC	No.	PROPORTION TREATED, %[a]	ODDS RATIO	95% CONFIDENCE INTERVAL	P VALUE
Age group, y					
≤40	359	89.4	1.0	Referent	–
41–60	1816	87.6	0.8	(0.6–1.2)	.25
61–80	2011	88.6	0.8	(0.6–1.2)	.36
>80	377	89.1	0.9	(0.5–1.5)	.65
Female	2224	87.9	1.0	Referent	–
Male	2339	88.7	1.0	(0.8–1.2)	.93
Race/ethnicity					
White	2557	88.1	1.0	Referent	–
Other	2006	88.5	1.0	(0.8–1.2)	.71
Insurance					
Private	1145	86.9	1.0	Referent	–
Medicaid	358	89.7	1.1	(0.8–1.7)	.63
Medicare	2620	88.6	1.0	(0.8–1.2)	.38
Other	440	88.6	1.1	(0.8–1.6)	.59
Length of stay, d					
<2	1163	90.0	1.0	Referent	–
2–4	2139	86.9	0.8	(0.6–1.0)	.021
>4	1261	89.0	0.9	(0.7–1.2)	.58
Surgical service	2259	86.3	1.0	Referent	–
Medical service	2304	90.2	1.3	(1.1–1.6)	.014
Charlson Comorbidity Index					
0	1129	82.9	1.0	Referent	–
1	1181	88.9	1.6	(1.2–2.0)	<.001
2	977	88.7	1.6	(1.2–2.0)	<.001
3	600	92.8	2.6	(1.8–3.7)	<.001
4	298	92.3	2.4	(1.5–3.8)	<.001
≥5	378	90.7	1.9	(1.3–2.8)	.011

[a]Proportion of patients treated with a first-line antihypertensive medication.

sex, non-white race, longer LOS (>4 days), and higher comorbidity scores had higher multivariate-adjusted odds of receiving antihypertensive medications during hospitalization. Receipt of a hospitalist consultation tended to increase the odds of antihypertensive use, but this was of marginal significance (OR, 1.4; 95% CI, 1.0–1.9). Among treated surgical patients (Table IV), only increased comorbidity was associated with higher odds of receiving first-line antihypertensive agents.

The proportion of patients receiving each antihypertensive drug class is listed in Table V and indicates a high proportion of BB and ACE inhibitor use in this setting. Patients frequently received multiple agents. BBs (60.7%) and ACE inhibitors (39%) were most often prescribed.

DISCUSSION

The present report represents an initial description of the prescribing patterns for antihypertensive medications among inpatients with a hypertension diagnosis. These data suggest that patients who were younger, female, non-white, and cared for by nongeneralists were less likely to receive antihypertensive therapy or first-line therapy as inpatients. This phenomenon of decreased treatment among younger patients mirrors the trends seen over time in the outpatient setting based on NHANES data. Our sample contrasted with NHANES data, however, in that women with known hypertension were less likely to be prescribed antihypertensive medications during their inpatient stay. The reasons for this are unclear, but warrant further investigation.

Other factors were significantly associated with higher adjusted odds of antihypertensive medication treatment as well. It is likely that the presence of Medicaid insurance may be confounded by age with regards to odds of antihypertensive medication use. Patients with increasing levels of comorbidity were more likely to receive antihypertensive medications when compared with less complex patients. Patients with multiple (>5) comorbid illnesses,

Table III. Summary of the Logistic Regression Model for All Surgical Hypertensive Inpatients Predicting Treatment With Any Antihypertensive Medication

Patient Characteristic	No.	Proportion Treated, %[a]	Odds Ratio	95% Confidence Interval	P Value
Age group, y					
≤40	249	64.3	1.0	Referent	–
41–60	1000	77.0	1.9	(1.4–2.6)	<.001
61–80	956	83.5	2.3	(1.6–3.3)	<.001
>80	118	86.4	2.5	(1.3–4.8)	.004
Female	1191	75.7	1.0	Referent	–
Male	1132	82.0	1.5	(1.2–1.8)	<.001
Race/ethnicity					
White	1443	77.0	1.0	Referent	–
Other	880	81.7	1.4	(1.1–1.8)	.002
Insurance					
Private	812	71.9	1.0	Referent	–
Medicaid	124	81.5	1.4	(0.9–2.4)	.26
Medicare	1202	84.2	1.4	(1.1–1.9)	.073
Other	185	71.9	0.9	(0.6–1.3)	.082
Length of stay, d					
<2	408	75.0	1.0	Referent	–
2–4	1303	76.7	1.1	(0.8–1.4)	.54
>4	612	85.8	1.7	(1.2–2.4)	.002
No medical consult	1996	77.8	1.0	Referent	–
Medical consult	327	85.0	1.4	(1.0–1.9)	.075
Charlson Comorbidity Index					
0	796	71.2	1.0	Referent	–
1	574	79.8	1.5	(1.1–1.9)	.005
2	452	82.1	1.5	(1.1–2.0)	.012
3	255	85.1	1.8	(1.2–2.7)	.003
4	102	91.2	2.9	(1.4–6.0)	.003
≥5	144	86.1	1.7	(1.0–2.9)	.043

[a]Proportion of patients treated with any antihypertensive medication.

however, were less likely to be treated. Perhaps such patients were so complex that antihypertensive medications might reasonably have been held, or this might represent evidence of therapeutic inertia. It is notable, however, that in the hospital setting, insurance status was not a strong predictor of prescribing antihypertensive medications or first-line agents. This was not the case in a nationally representative sample of hypertensive outpatients from the NHANES study whose likelihood of being treated was 36% when compared with 69% among those with private insurance.[15]

It is also notable that the proportion of treated patients and the proportion of patients taking first-line agents varied by service line. During the past 15 years, there has been a dramatic increase in the number of hospital medicine specialists in US hospitals. These physicians are primarily internal medicine and family medicine specialists who have good general knowledge of the principles of hypertension care. Thus, it is not surprising that generalists might more readily prescribe antihypertensive medications than their subspecialist and surgical colleagues. One might posit that hospitalist consultation for hypertensive patients might improve the likelihood of appropriate antihypertensive prescribing among surgical patients. These data suggest, however, that surgical patients receiving medical consultation were only marginally more likely to be treated with antihypertensive medications or first-line agents. However, it is likely that other clinical variables not included in this data set, such as the reason for consultation, might alter the results of this subgroup analysis. Other end points worthy of further investigation regarding the utility of hospitalist consultation in hypertensive surgical and subspecialty patients include the degree of BP control and measures of antihypertensive medication prescribing at discharge.

We were also able to capture descriptive information on the classes of antihypertensive medications prescribed for inpatients. In our dataset, the proportion of thiazide diuretic use in this setting was low

Table IV. Summary of the Logistic Regression Model for All Surgical Hypertensive Inpatients Prescribed Any Antihypertensive Medication Predicting Treatment With a First-Line Antihypertensive Medication

Patient Characteristic	No.	Proportion Treated, %[a]	Odds Ratio	95% Confidence Interval	P Value
Age group, y					
≤40	160	89.4	1.0	Referent	–
41–60	770	84.9	0.7	(0.4–1.2)	.19
61–80	798	88.0	0.8	(0.5–1.5)	.57
>80	102	93.1	1.5	(0.6–4.1)	.38
Female	902	86.5	1.0	Referent	–
Male	928	87.7	1.0	(0.8–1.4)	.78
Race/ethnicity					
White	1111	86.7	1.0	Referent	–
Other	719	87.8	1.1	(0.8–1.5)	.63
Insurance					
Private	584	85.5	1.0	Referent	–
Medicaid	101	90.1	1.2	(0.6–2.4)	.45
Medicare	1012	88.2	0.9	(0.6–1.3)	.58
Other	133	83.5	0.9	(0.5–1.4)	.49
Length of stay, d					
<2	306	88.2	1.0	Referent	–
2–4	999	84.6	0.7	(0.5–1.1)	.14
>4	525	91.2	1.3	(0.8–2.0)	.33
No medical consult	1552	87.1	1.0	Referent	–
Medical consult	278	87.1	1.1	(0.7–1.6)	.75
Charlson Comorbidity Index					
0	567	80.8	1.0	Referent	–
1	458	88.0	1.7	(1.2–2.4)	.005
2	371	89.2	1.8	(1.2–2.8)	.003
3	217	92.6	2.9	(1.6–5.1)	<.001
4	93	94.6	3.9	(1.5–10.1)	.004
≥5	124	91.1	2.2	(1.1–4.2)	.025

[a]Proportion of patients treated with a first-line antihypertensive medication.

compared with reports of outpatient prescribing rates.[16, 17] The proportion of BBs and ACE inhibitors was high, perhaps related to the treatment of associated conditions such as acute coronary syndromes and congestive heart failure. Similarly, direct vasodilator and central α-blocker use were higher than would be expected in routine outpatient use.

LIMITATIONS

It is important to note that this report has several limitations. First, our use of administrative data to establish a diagnosis of hypertension may not be as accurate for case finding as other methods, such as chart review. The use of administrative data to assign comorbid diagnoses in inpatient and outpatient health services research is widespread, however.[16,17] Previous research indicates that the degree of agreement (κ) between administrative data and chart review for the diagnosis of hypertension is moderate at 0.58 in one series.[18] Further, this series listed a low sensitivity for administrative data of

Table V. Antihypertensive Medications Used

Medication Class	Patients Receiving Medication, %
Angiotensin-converting enzyme inhibitor	39.0
Angiotensin receptor blocker	17.0
β-Blocker	60.7
Thiazide diuretic	14.3
Calcium channel blocker	
Dihydropyridine	10.9
Nondihydropyridine	25.0
α-Blocker	9.6
Direct vasodilator	16.8

59.9% but a higher degree of specificity at 94.6%. Given these test characteristics, our case-finding strategy may have underestimated the prevalence of hypertension in our hospital. As previously noted, the prevalence of inpatient hypertension in another series was high at >50%, but our prevalence of 23% was lower than the prevalence in the general

population (approximately 29%).[3] If identification of hypertensive patients in administrative data is somehow linked to antihypertensive medication prescribing, then it is also possible that our treatment estimates are higher than we might have had using other case-finding strategies.

It is also possible that our analysis failed to account for clinical factors that may have influenced the odds of antihypertensive medication prescribing. We attempted to reduce the likelihood of this phenomenon by excluding intensive care unit patients, patients with a primary or secondary diagnosis of hypotension or sepsis syndromes, and patients with acute renal failure, groups of patients whose antihypertensive medications might appropriately have been withheld. We also included an index of comorbidity, the Charlson Index, in our adjusted analyses. Finally, the present dataset lacked information on vital signs. This information would have been helpful in order to identify patients with low BP for which antihypertensive medications would appropriately have been withheld, but also to measure the severity of hypertension among inpatients. Future studies in this area should include manual chart review or other method of case finding for hypertension diagnosis and patient level vital sign information.

CONCLUSIONS

This report details the patterns of antihypertensive medication prescribing at a university teaching hospital for patients with a diagnosis of hypertension. It appears that patients who were younger, female, and cared for by nongeneralists were less likely to be prescribed antihypertensive medications or to be prescribed first-line agents during hospitalization. Hypertension identified in the inpatient setting tends to persist in the outpatient setting, [9,19] and it will be useful to address disparities in prescribing among inpatients as a means of improving overall hypertension control rates.

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