Rate Control With Beta-blockers Versus Calcium Channel Blockers in the Emergency Setting: Predictors of Medication Class Choice and Associated Hospitalization

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ABSTRACT

Objectives: Rate control is an important component of the management of patients with atrial fibrillation (AF). Previous studies of emergency department (ED) rate control have been limited by relatively small sample sizes. We examined the use of beta-blockers (BBs) versus nondihydropyridine calcium channel blockers (CCBs) in ED patients from 24 sites and the associated hospital admission rates.

Methods: In this preplanned substudy, we examined chart data on AF patients who visited one of 24 hospital EDs in Ontario, Canada, between April 2008 and March 2009. We describe the proportion of patients who received either a BB or a CCB, had a heart rate < 110 beats/min 2 hours later, and had any complications. We used hierarchical logistic regression modeling to determine the predictors of BB versus CCB use and to assess the between-hospital variation in use of BBs versus CCBs. Solely in patients who had no rhythm control attempts, we examined the difference in the probability of hospital admission after propensity score matching patients by medication class.

Results: Of the 1,639 patients who received either a BB (n = 429) or a CCB (n = 1,210), 70.9% of the patients who received a BB had successful rate control versus 66.1% for a CCB. Complications were rare (2.4%), and the large majority were hypotension (2.0%). In adjusted analyses, predictors of receiving a BB (compared to a CCB) included already being on a BB, being sent in from a doctor's office, or being seen at a teaching hospital. In contrast, patients with evidence of heart failure, prior use of a CCB, a higher presenting heart rate, or a successful pharmacologic cardioversion (vs. no attempt) or who were seen at the highest AF volume EDs were significantly less likely to receive a BB, compared to a CCB. Systematic between-hospital differences accounted for 8% of the variation in BB versus CCB use. Hospital characteristics accounted for the large majority of that variation: after accounting for patient characteristics the between-hospital variation decreased by a relative 2.8%. By further adjusting for hospital characteristics, it decreased by a relative 74.7%. Among propensity score–

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matched patients with no rhythm control attempts, more CCB patients were admitted (51.6%) compared to BB patients (40.0%; difference of 11.6%; 95% confidence interval = 7.9%–16.2%).

Conclusions: In this study of 24 EDs, CCBs were used more frequently for rate control than BBs, and complications were rare and easily managed using both agents. Variation between hospitals in BB versus CCB use was predominantly due to hospital characteristics such as teaching status and AF volumes, rather than different case mix. Among patients who did not receive attempts at rhythm control, use of a BB for rate control was associated with a lower rate of hospitalization.

Atrial fibrillation (AF) is common in the emergency department (ED) setting, and the numbers continue to rise.[1,2] There is substantial variation in the emergency management of AF,[3,4] which may include rate control, rhythm control, anticoagulation, and potentially hospital admission.

Rate control is typically achieved with either a beta-blocker (BB) or a nondihydropyridine calcium channel blocker (CCB).[4,5] Some physicians begin with intravenous (IV) medication, followed by or provided concomitantly with the oral version, while others use only oral medication, depending on the patient's heart rate.[6] Once the heart rate is less than 110 beats/min (or 100 beats/min, depending on the guidelines consulted),[6–8] the patient can be sent home on that medication, with outpatient follow-up care for ongoing management.[5,9] Guidelines do not recommend one medication class over the other, likely because comparison of BBs to CCBs has received relatively little study in the ED.[10] The largest randomized controlled trial includes only 52 patients,[11] and the largest observational studies include only 259 patients or were restricted to a subset of AF patients (e.g., in whom a rhythm control strategy was an option).[4,12] Neither study used inferential statistics to assess the adjusted association of BB versus CCB use with outcomes.

We performed a 24-site study of ED patients with a primary diagnosis of AF to derive a prediction tool for safe ED discharge.[13] As part of that study we assessed the use of rate control medications, success rates with each class, and complications. In this planned substudy we had several goals. We wanted to establish the variables that are independently associated with use of each medication class in the emergency setting, to determine whether there are strong factors that are currently driving medication selection; if so, these factors would need to be addressed in future guidelines. Because we believe that physicians practicing at one site are likely to have similar practice patterns (a culture of practice that is promoted by the hiring of physicians who were trained at the site and by continuing medical education activities such as hospital rounds), we evaluated site-level variation in the choice of BB versus CCB, examining the influence of patient-level characteristics on site-level variation. Finally, we aimed to assess the adjusted association between hospitalization and medication class provided.

METHODS

Study Design

This was a planned substudy of the retrospective cohort study AFTER (Atrial Fibrillation in the Emergency Room);[13] details of the AFTER study have been described previously. We obtained research ethics board approval from all 24 participating sites.

Patient Population

Adult patients with a primary (first listed) ED diagnosis of AF between April 1, 2008, and March 31, 2009, were eligible. We included only the index visit (the first visit per patient within the study period). Based on our previous work, which found markedly different outcomes in patients for whom AF was listed as another diagnosis, we excluded patients who had any primary diagnosis that was not AF (including atrial flutter).[14] We excluded patients under 18 years of age and those who received *both* a CCB and a BB in the ED, as they constituted a different group than the cohorts we aimed to compare in this study.

Patients were selected from EDs in Ontario; Ontario is Canada's most populous province, with an ethnically diverse population of 13 million. We used a stratified sampling strategy, which was employed to allow the results to be applicable to the larger population of emergency AF patients in the province. First we stratified by hospital site, choosing a representative proportion of tertiary/teaching sites, large community sites, intermediate community sites, and small sites. Next, within those sites we randomly selected a representative number of patients (for each site type) within that site. Sites and patients were identified from the Canadian Institute for Health Information (CIHI) National Ambulatory Care Reporting System

(NACRS), a mandatory, province-wide administrative data set that contains virtually all ED visits in the province of Ontario.[15] Once the index visit was identified in NACRS, trained chart abstractors took the NACRS list of eligible patients to each hospital and abstracted their charts (i.e., data came from patient charts, *not* from administrative data sets). Due to study funding limitations, the initial list of eligible sites in NACRS was limited to those sites that were within daily driving distance of the Greater Toronto Area or had a sister site that was within that distance.[13] A sample of 5% of study charts were selected for reabstraction;[16] inter-rater agreement was substantial to excellent.[17]

Solely for analyses of hospital admission and ED length of stay (LOS), we excluded patients who had an attempted (regardless of success) cardioversion, given that the management goals for a cardioverted patient are different than for a patient who is simply rate-controlled (i.e., rate control in the former patient is typically provided as a preamble to cardioversion, rather than the goal in and of itself).

Data Collection

Trained physician abstractors entered chart data into a case report form using custom software, which was securely transmitted to our research institute and subsequently linked to copies of other province-wide data sets. These data sets include the Registered Persons Database, CIHI's Discharge Abstract Database, and the Ontario Health Insurance Plan data set,[18,19] which provided subsequent deaths (including out of hospital deaths), hospitalizations, and any outpatient health visits or procedures, respectively. Ontario has universal health care coverage, so these data sets include the large majority of medically necessary health care visits and procedures in the province.

Based on AF guidelines, time to medication onset, and time for laboratory results to become available (which may influence ED discharge decisions), rate control success was defined a priori as a heart rate $\leq$ 110 beats/min within 2 hours of last medication administration.[7,9] Hypotension was defined as a systolic blood pressure $\leq$ 80 mm Hg, or $\leq$ 90 mm Hg and also given treatment (e.g., fluid bolus, cardioversion). Breathing complications were defined as bagging or intubation.

Outcome Measures

The outcome measures included BB versus CCB use (including between-hospital variation), hospital admission, ED LOS, successful rate control, and complications.

Data Analysis

We use descriptive statistics to describe the proportion of patients who received each rate-control medication, success rates by class, and complications. We decided a priori that missing data on heart rate 2 hours after medication administration would be counted as "unsuccessful" rate control, as a lack of nursing documentation is typically due to an unchanged status;[12] to assess the impact of this assumption we performed a "worst-case scenario" sensitivity analysis. Due to an agreement with CIHI, we do not report results on five or fewer patients (for privacy reasons) or any results that would allow that number to be calculated; in such instances the result is marked with an asterisk.

To evaluate the observed variables that were associated with receipt of a BB (vs. a CCB) while in the ED, we used a hierarchical regression analysis that included site-specific random effects, to account for clustering of patients within hospital EDs. Specifically, we fit a hierarchical logistic regression model with random hospital-specific intercepts. To test whether the variation between hospitals in the rate control agent provided is determined more by hospital characteristics than by patient characteristics (i.e., different types of patients presenting to different EDs), we fit three hierarchical regression models and examined the change in the variation of site-specific random effects.[20]

Initially we used a null model to regress medication class on only the site-specific random effects. This allowed us to quantify the magnitude of the between-site variation in BB versus CCB use before accounting for patient or hospital characteristics. Next we added patient-level variables to the model, to determine the reduction in between-site variation in medication class use that was due to patient characteristics. Finally, we added hospital-level characteristics (hospital-type and annual ED AF volumes) and again assessed the change, if any, in between-site variation in BB use. A large decrease in between-site variation with the addition of these variables would suggest that these additional variables account for much of the systematic between-hospital differences in use by medication class, whereas little change in the variation suggests that choice of medication class is mostly dependent on something unique to each site. Random effects were assumed to follow normal distribution on a log-odds scale with an unstructured covariance matrix. Finally,

to further compare the size of the effect of the ED to the effect of patient-level characteristics, we calculated the median odds ratio (OR), which is a measure of the magnitude of the general contextual effect of the EDs.[20] We compared it to the size of the ORs of the individual patient-level characteristics in the model.

To determine the association of the medication class with hospital admission, as well as to compare ED LOS (in patients who did not receive rhythm control attempts), we employed propensity score matching. Propensity score methods are used to reduce confounding due to measured covariates; matching on the propensity score aims to simulate a randomized trial using observational data.[21–24] Specifically, we used logistic regression with Firth's bias-adjusted estimates to regress receipt of either a BB or CCB on 35 relevant patient- and system-level variables, based on the published literature:[4,12,13] patient demographics, comorbidities, prior medications, presenting vital signs (including heart rate), triage score, laboratory and electrocardiogram results, and final rhythm in the ED (see specific variables in Table 3). We included the adjusted diagnosis group (ADG) score, which is similar in principle to the Charlson comorbidity index that is used in studies of hospitalized patients, but it is used in an ambulatory patient population; it is based on diagnoses from ambulatory physician visits and hospital admissions.[25] Patients were matched on the logit of the propensity score using 1:1 matching without replacement and a caliper width of 0.2 of the standard deviation (SD) of the logit of the propensity score.[26,27]

Because we suspected that the medication class utilized is strongly related to physician training (and comfort with the medications) and because training varies predominantly by hospital type (the majority of emergency physicians who work at teaching sites have 5 years of emergency medicine training, mostly provided at a teaching sites, while at community sites the physicians usually receive 2 or 3 years of training through the College of Family Physicians of Canada), in addition to matching on the propensity score we also matched on hospital type (community or teaching). This ensured that a potential match had to be drawn from within the same hospital type. Because of the small number of eligible patients seen at small sites (n = 13), we excluded patients seen at small sites from the propensity score analysis.

To ensure that our admission results were not due to systematic differences within each site, we performed a sensitivity analysis in which we matched on both the propensity score *and* the specific ED at which the patient was treated. Balance in baseline covariates was evaluated by standardized differences.[28] Differences in the probability of admission to hospital and ED LOS were assessed in the matched patients using McNemar's test.[29] All analysis were performed using SAS software (Version 9.3, SAS Institute Inc.).

RESULTS

Baseline Characteristics

There were 3,510 patients enrolled in the original AFTER cohort, of whom 1,890 (53.8%) received a BB or a nondihydropyridine CCB while in the ED. After removal of 251 patients who received *both* a BB and a CCB, there were 1,639 eligible patients (Figure 1). Across the 24 sites use of CCBs ranged from 22% to 60%, while BB use ranged from 4% to 24% (Figure 2). At all sites rate control was performed more often with CCBs than BBs (Figure 3): 1,210 patients (74%) received a CCB and 429 (26%) received a BB. The median presenting heart rate was slightly higher in

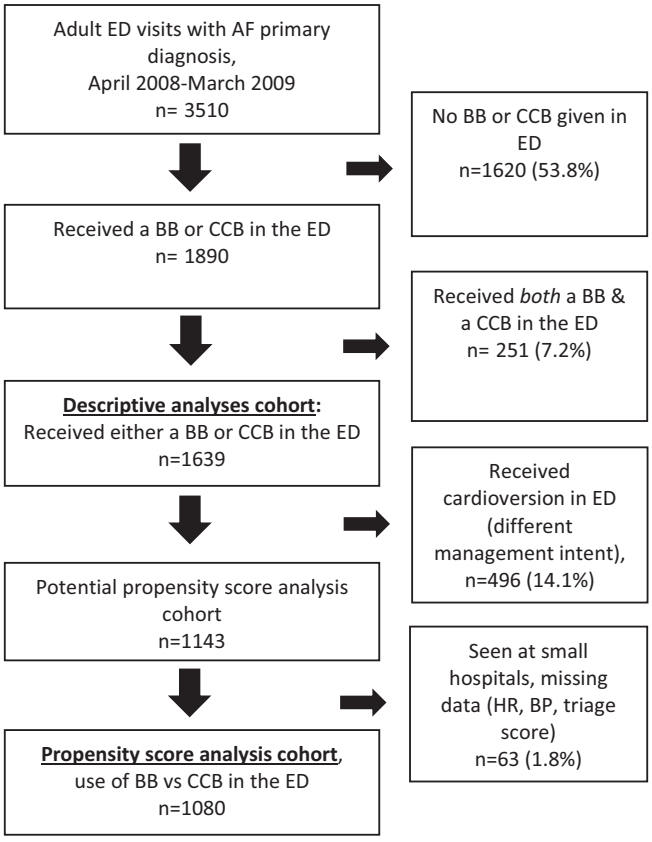

Figure 1. Study flow diagram. AF = atrial fibrillation; BB = beta-blocker; BP = blood pressure; CCB = calcium channel blocker; HR = heart rate.

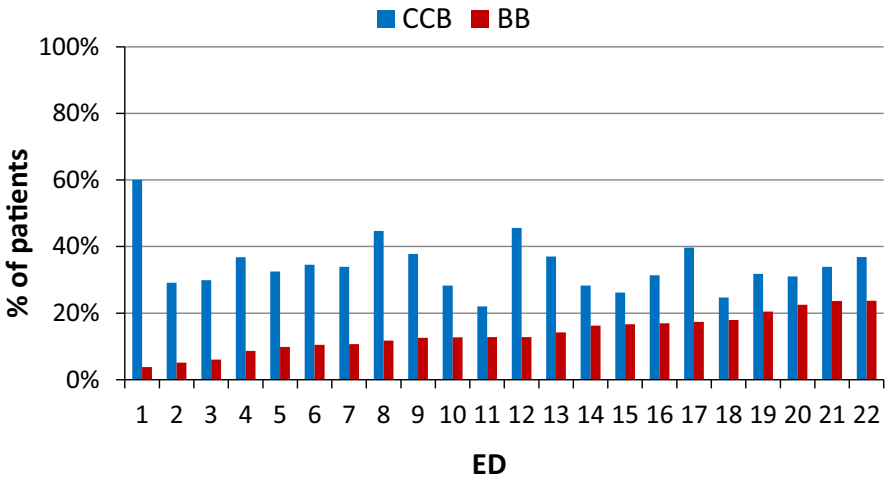

Figure 2. Use of beta-blockers versus calcium channel blockers in all 3510 AF patients, by ED. Three sites are condensed to avoid reporting small cell sizes.

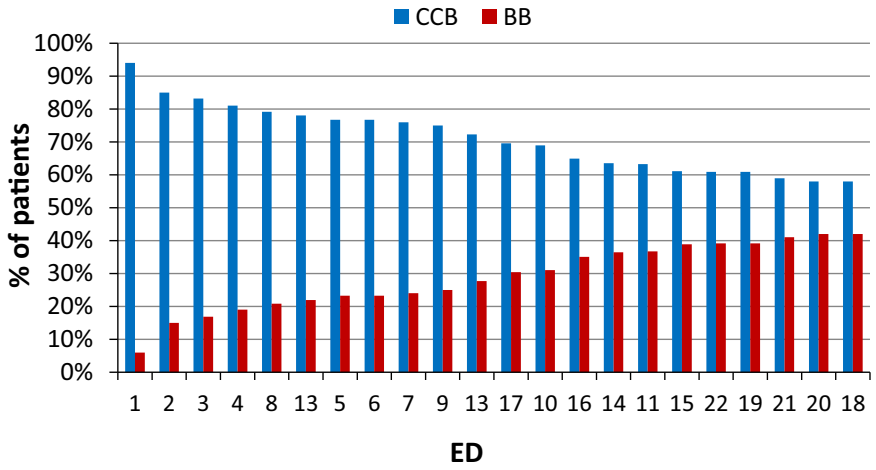

Figure 3. Among the 1639 (out of a total of 3510) patients who received either a beta-blocker or calcium channel blocker, percentage who received a beta-blocker versus calcium channel blocker by ED. BB = beta-blocker; CCB = calcium channel blocker.

patients given a CCB (131 beats/min) versus a BB (120 beats/min; Table 1). Eighteen percent of the cohort was successfully cardioverted (either electrically or pharmacologically) to sinus rhythm during their ED stay.

Medication Administration and Success Rates

The average doses of each rate control medication and the success rates are shown in Table 2. Rate control was successful in 67% of patients who received either a BB or a CCB, with slightly higher rates of success with BBs (70.9%) compared to CCBs (66.1%). However, 30 patients who received metoprolol had an unknown success status (no heart rate documented within 2 hours of administration); these patients were counted as unsuccessful and therefore the BB rate may be an underestimate of the success rate. The median time between IV and oral BB administration was shorter (29 minutes, interquartile range [IQR] = 7–110 minutes) than for CCBs (80 minutes, IQR = 20–151 minutes). Unadjusted admission rates were lower in patients who received a BB (42.6%) versus those who received a CCB (55.3%; difference = 12.7%; 95% confidence interval [CI] = 7.0–18.4). The difference was diminished when assessed only by IV forms: metoprolol 49.8% versus diltiazem 56.4% (difference = 6.6%; 95% CI = –0.3 to 13.5).

Complications

Complications following use of a rate control agent occurred in 40 (2.4%; 95% CI = 1.7%–3.3%) patients, 33 of which were hypotension (2.0%; 95% CI = 1.4%–2.8%) and seven (0.4%; 95% CI = 0.2%–0.9%) were an arrhythmia. Among the latter patients, fewer than six (exact numbers cannot be reported due to CIHI agreement) had an attempted

Table 1
Patient Characteristics by Rate Control Medication Class Administered

Characteristic	Either BB or CCB, *n* = 1,639 (%)	CCB, *n* = 1,210 (%)	BB, *n* = 429 (%)	p-value
Demographics				
Age (y), median (IQR)	72.0 (60.0–80.0)	72.0 (59.0–81.0)	72.0 (61.0–80.0)	0.29
Age (y), mean ± SD	69.3 ± 14.7	69.0 ± 14.9	70.1 ± 14.0	0.15
Female	864 (52.7)	644 (53.2)	220 (51.3)	0.49
Income quintile (5 = highest)				
1	289 (17.6)	224 (18.5)	65 (15.2)	0.25
2	312 (19.0)	223 (18.4)	89 (20.7)	
3	301 (18.4)	227 (18.8)	74 (17.2)	
4	339 (20.7)	239 (19.8)	100 (23.3)	
5	398 (24.3)	297 (24.5)	101 (23.5)	
Rural residence	40 (2.4)	26 (2.1)	14 (3.3)	0.20
Came from				
Home	1,520 (92.7)	1,140 (94.2)	380 (88.6)	<0.001*
LTC facility	64 (3.9)	41 (3.4)	23 (5.4)	
Other†	55 (3.4)	29 (2.4)	26 (6.1)	
Past medical history				
AF	757 (46.2)	546 (45.1)	211 (49.2)	0.15
Stroke or transient ischemic attack	98 (6.0)	63 (5.2)	35 (8.2)	0.03*
Heart failure	337 (20.6)	242 (20.0)	95 (22.1)	0.35
Diabetes mellitus	265 (16.2)	186 (15.4)	79 (18.4)	0.14
Hypertension	887 (54.1)	641 (53.0)	246 (57.3)	0.12
CHADS-VASc score ≥ 2	1,165 (71.1)	846 (69.9)	319 (74.4)	0.08
HAS-BLED[35] ≥ 3	394 (24.0)	276 (22.8)	118 (27.5)	0.05*
Valvular disease	132 (8.1)	90 (7.4)	42 (9.8)	0.12
Acute myocardial infarction	164 (10.0)	105 (8.7)	59 (13.8)	0.003*
COPD	123 (7.5)	104 (8.6)	19 (4.4)	0.01*
Chronic renal failure	72 (4.4)	46 (3.8)	26 (6.1)	0.05*
Cancer‡	174 (10.6)	123 (10.2)	51 (11.9)	0.32
Dementia	76 (4.6)	58 (4.8)	18 (4.2)	0.61
ADG score, median (IQR)	10.0 (7.0–13.0)	10.0 (6.0–13.0)	10.0 (7.0–13.0)	0.01*
Medications prior to ED visit (*patients may be in more than one group*)				
Warfarin	374 (22.8)	272 (22.5)	102 (23.8)	0.58
BB	510 (31.1)	293 (24.2)	217 (50.6)	<0.001*
Nondihydropyridine CCB	149 (9.1)	139 (11.5)	10 (2.3)	<0.001*
Digoxin	100 (6.1)	73 (6.0)	27 (6.3)	0.85
Antiarrhythmic	150 (9.2)	112 (9.3)	38 (8.9)	0.81
ED visit				
Hospital type				
Community	1213 (74.0)	951 (78.6)	262 (61.1)	<0.001*
Small	18 (1.1)	11 (0.9)	7 (1.6)	
Teaching	408 (24.9)	248 (20.5)	160 (37.3)	
Presenting vital signs, median (IQR)				
Heart rate (31 patients missing values)	130.0 (110.0–148.0)	131.0 (112.0–150.0)	120.0 (101.0–140.0)	<0.001*
Systolic BP (47 patients missing values)	133.0 (118.0–150.0)	133.0 (119.0–150.0)	132.0 (115.0–150.0)	
ED triage group (1–2 highest acuity; 25 patients missing values)5				
1–2	1,314 (80.2)	990 (81.8)	324 (75.5)	0.03*
3/4/5	300 (18.3)	202 (16.7)	98 (22.8)	

(Continued)

Table 1 (continued)

Characteristic	Either BB or CCB, *n* = 1,639 (%)	CCB, *n* = 1,210 (%)	BB, *n* = 429 (%)	p-value
Arrival by ambulance	572 (34.9)	429 (35.5)	143 (33.3)	0.43
Initial ECG wide QRS (>120 mm)	161 (9.8)	113 (9.3)	48 (11.2)	0.44
Chest x-ray showing pulmonary edema	176 (10.7)	147 (12.1)	29 (6.8)	0.002*
Furosemide given in ED	182 (11.1)	154 (12.7)	28 (6.5)	<0.001*
Electrical cardioversion attempted	163 (9.9)	125 (10.3)	38 (8.9)	0.38
Pharmacologic cardioversion attempted	395 (24.1)	310 (25.6)	85 (19.8)	0.05*
Successful cardioversion in the ED	289 (17.6)	227 (18.8)	62 (14.5)	0.67
Evidence of heart failure§	460 (28.1)	362 (29.9)	98 (22.8)	0.01*
Laboratory measures				
Troponin, conventional, positive‖	204 (12.4)	149 (12.3)	55 (12.8)	0.79
Creatinine > 200 mmol/L (2.26 mg/dL)	39 (2.4)	26 (2.1)	13 (3.0)	0.30
INR level				
<2	1,245 (76.0)	941 (77.8)	304 (70.9)	0.06
2–3	180 (11.0)	120 (9.9)	60 (14.0)	
>3	82 (5.0)	63 (5.2)	19 (4.4)	
Not done	132 (8.1)	86 (7.1)	46 (10.7)	
Disposition details				
Admitted to hospital from ED	850 (51.9)	667 (55.1)	183 (42.7)	<0.001*
Among discharged patients, consultant seen	229/789 (29.0)	167/543 (30.8)	62/367 (16.9)	<0.001*
Final rhythm in ED				
AF	782 (47.7)	552 (45.6)	230 (53.6)	0.02*
Normal sinus	769 (46.9)	591 (48.8)	178 (41.5)	
Other or unknown	88 (5.4)	67 (5.5)	21 (4.9)	

ADG = adjusted diagnosis group; AF = atrial fibrillation; BB = beta-blocker; BP = blood pressure; CCB = calcium channel blocker; COPD = chronic obstructive pulmonary disease; ECG = electrocardiogram; INR = international normalized ratio; IQR = interquartile range; LTC = long-term care.
$p \leq 0.05$.
†Large majority were sent from a physician's office.
‡Includes major cancers (basal cell and squamous cell cancers of the skin were excluded).
§Includes a past medical history of heart failure, a history and physical examination findings consistent with heart failure, evidence on chest x-ray, or administration of furosemide in the ED.
‖Any level above laboratory cutoff (serial troponins were not collected).

pharmacologic cardioversion (i.e., also received an antiarrhythmic medication). Nine (2.1%; 95% CI = 1.0%–3.9%) of the complications occurred after administration of a BB, 31 (2.6%; 95% CI = 1.7–3.6) after a CCB. Twenty-eight (82%) of the 33 hypotensive episodes responded to fluids; other management approaches included observation, oxygen, IV calcium, and cardioversion. Of the seven patients with an arrhythmia complication, the two arrhythmias reported were bradyarrhythmias and runs of ventricular tachycardia; management approaches included observation, fluid bolus, atropine, and IV calcium. There were no reported breathing complications (e.g., bagging or intubation) and no deaths.

Adjusted Predictors of Medication Class Choice

In the hierarchical regression analysis of predictors of rate control medication class used, patients who were already on a BB did not come from home (i.e., sent from a doctor's office) or were seen at a teaching hospital were more likely to receive a BB versus a CCB (Figure 4). Patients with evidence of heart failure or prior use of a CCB, who had a higher presenting heart rate, who had a successful pharmacologic cardioversion (versus no attempt), or who were seen at the highest AF volume EDs were significantly less likely to receive a BB, relative to a CCB.

Patient-level Versus Hospital-level Variation in Medication Class Use

The between-site variance estimate in the null model was 0.2775, for an intraclass correlation coefficient (ICC) of 0.078 (Table 3).[30] This indicates that 7.8% of the variation in medication class use was at the hospital level. After the inclusion of patient-level variables into the model it remained similar (0.2696), and it decreased to 0.07018 after the inclusion of hospital-

Table 2
Rate Control Medications, Success Rates, and Average Doses, Among 1,639 Patients Given Either a BB or a Nondihydropyridine CCB

	n (%)	Success (%)	95% CI	Median Dose, mg	IQR
BBs					
All	429	295/416* (70.9)	66.3–75.2	–	–
Metoprolol	385 (23.5)	275 (71.4)	66.6–75.9	IV: 5.0	5.0–10.0
				PO: 25.0	25.0–50.0
Atenolol (PO)	29 (1.8)	21 (72.4)	52.8–82.3	50.0	25.0–50.0
Bisoprolol	21 (1.3)	*		*	
Acebutolol	†	†	†	200.0	200.0–200.0
Propranolol	†	†	†	1.25	0.5–2.0
Carvedilol	†	†	†	6.25	6.25–6.25
Esmolol	0 (0)	–	–	–	–
Nondihydropyridine CCBs					
All	1210 (73.8)	800 (66.1)	63.4–68.8	–	–
Diltiazem	1205 (73.5)	796 (66.1)	63.3–68.7	IV: 20.0	18.0–30.0
				PO: 60.0	30.0–120.0
Verapamil	8 (0.5)	†	†	IV: 5.0	5.0–5.0
				PO: 80.0	40.0–120.0

BB = beta-blocker; CCB = calcium channel blocker; IQR = interquartile range; IV = intravenous; IV = intravenous; PO = per os (oral).
*The 21 patients who received bisoprolol had missing data for successful rate control (due to a data collection software error), eight of whom had success rates documented for another BB received (e.g., IV metoprolol). The remaining 13 are removed from the denominator. In addition, 30 of the patients who received metoprolol had an unknown rate control status (no heart rate documented within 2 hours of administration); these were counted as "not successful"; therefore, this rate and the BB rate could be an underestimate.
†Small cell size (≤5 patients), not reported as per privacy agreement with the Canadian Institute of Health Information (CIHI).

level variables (models shown in Data Supplement S1, available as supporting information in the online version of this paper, which is available at https://doi.org/onlinelibrary.wiley.com/doi/10.1111/acem.13303/full). The ICCs were 0.076 and 0.021, respectively. Therefore, by including patient characteristics, the between-site variation decreased by a relative 2.8%, while further adjusting for two hospital characteristics (teaching status and AF volumes) decreased the between-site variation by a relative 74.7%.

The median ORs were 1.65, 1.64, and 1.29 for the null model, the model with patient-level characteristics added, and the model with patient and hospital-level characteristics, respectively (see Data Supplement S1 for calculation). Thus, when comparing two hospitals that are rank-ordered by their use of BB, the median increase in the odds of BB use was 65% across all such pairwise comparisons. In other words, if one compares two of the 24 hospitals at a time, with each comparison resulting in an OR, of all the possible comparisons the median of the resulting ORs would be 1.65.

Hospital Admission and ED LOS in Propensity Score–matched Patients Without a Rhythm Control Strategy

After removal of patients who were cardioverted and who had missing variables required for estimating the propensity score (Figure 1), there were 1,080 patients available for propensity score matching: 300 patients received a BB and 780 a CCB. A total of 249 (83%) patients who received a BB were matched to a patient who received a CCB, including matching within hospital type: balance in baseline covariates is shown in Table 4. Almost half (49.0%) of the matched patients who were given a CCB were admitted to hospital versus 39.4% of those who were given a BB ($p = 0.04$). Results were similar in the 217 pairs of patients who were matched both on the propensity score and on the ED where they were treated ($p = 0.01$). ED LOS was not statistically different (difference of 5 minutes) between matched groups.

DISCUSSION

To facilitate the implementation of future practice guidelines, it is important to establish current practice patterns: in this study of over 1,600 AF patients seen at 24 teaching, community, and small EDs, we found that physicians used CCBs more frequently than BBs. They were twice as likely to choose a BB for rate control if they worked in a teaching hospital and three times as likely if the patient was already on a BB or they were sent in from a physician's office, while they were three times more likely to choose a CCB if they

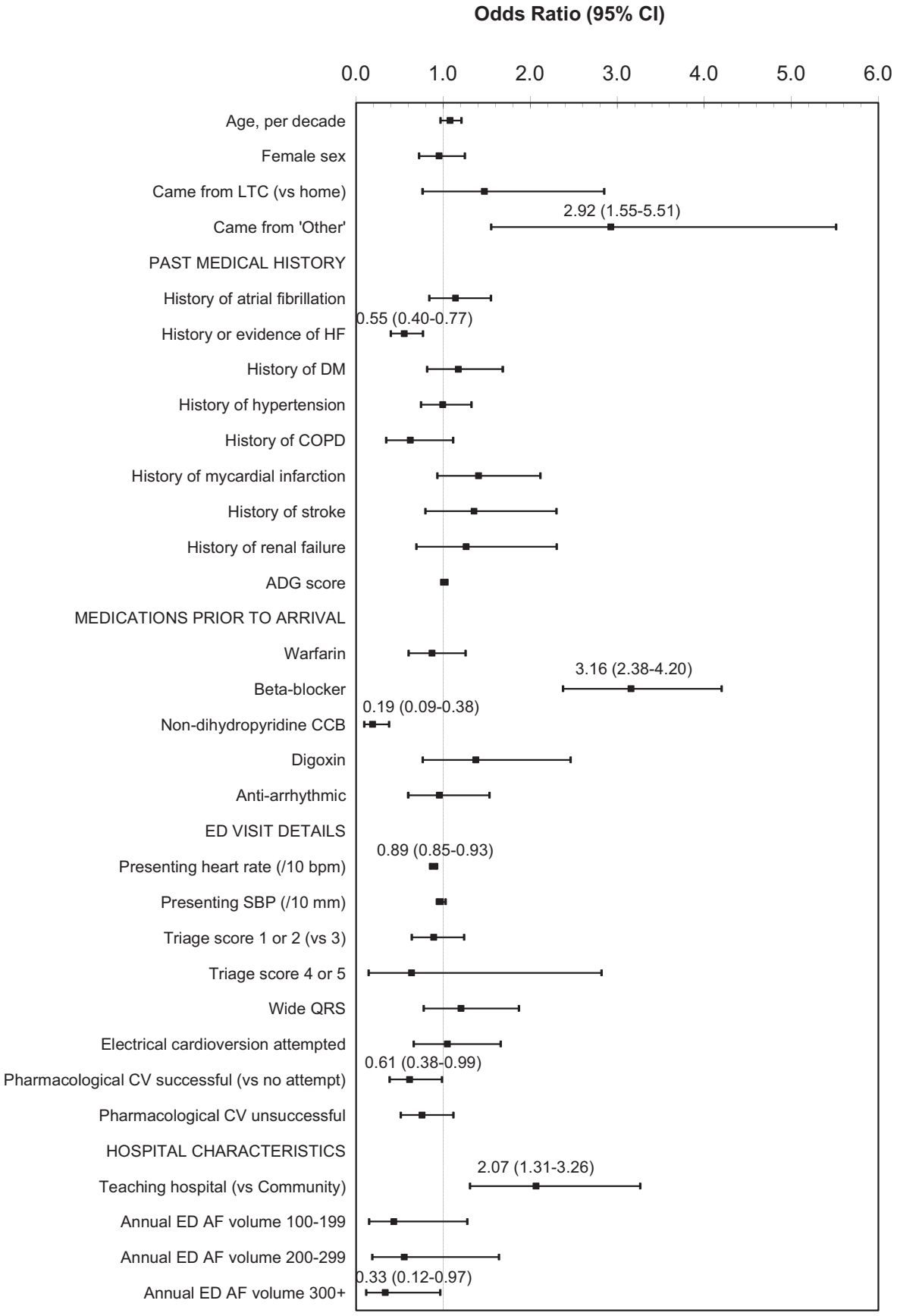

Figure 4. Adjusted predictors of receipt of a BB (vs. a CCB) in the ED. ADG = adjusted diagnosis group; AF = atrial fibrillation; BB = beta-blocker; CCB = calcium channel blocker; COPD = chronic obstructive pulmonary disease; DM = diabetes mellitus; HF = heart failure; LTC = long-term care.

Table 3
Variance Between Hospitals

Outcome	Model Variables	Variance	ICC	PCV
Hospitalization	Specific hospital only	0.2775	7.8%	–
	Hospital + patient characteristics	0.2696	7.6%	2.8%
	Hospital + patient characteristics + hospital characteristics	0.04292	2.1%	74.7%

ICC = intraclass correlation coefficient; PCV = proportional change in variance.

worked in a high-volume community center, 80% more likely for their patients with heart failure, and 12% more likely for a 10 beats/min increase in presenting heart rate. Aside from the presence of heart failure, presenting heart rate, and the meds patients were already on, there were no other patient-level characteristics that were independently associated with medication choice; therefore, it appears that future guidelines will not need to account for strong patient-level practice preferences in their recommendations.

While we found that CCBs were used more frequently in the ED than BBs, a previous study of 1,068 AF patients at eight EDs found that the opposite: 67% of the patients who received rate control received metoprolol, while 31% received diltiazem (compared to 24% metoprolol and 74% diltiazem in our study).[4] However, in that study all eight sites were teaching hospitals, and we found that teaching sites were significantly more likely to use BBs than community hospitals; therefore, our results are consistent with those findings. The same study noted large variation (up to sixfold) in use of individual rate control medications between sites, which was also consistent with the raw variation we found in the use of BBs by site (4%–24%), and CCBs (22%–60%).

When restricted to only patients who received rate control agents, we found that 7.8% of the variation in BB versus CCB use was at the hospital level. To provide clinical context for this result, the between-hospital variation in prescribing various evidence-based medications following an acute myocardial infarction ranges from 2.0% to 6.5%.[31] The median between-hospital variation reported for 145 outcomes in a database of randomized controlled trials was 6% (IQR = 1%–11%).[32] Therefore, the systematic between-hospital variation in BB versus CCB use for rate control is higher than average, likely due to the lack of evidence-based recommendations for one or the other medication class. In fact, given that guidelines do not recommend one over the other, the variation may be slightly lower than expected. Our results indicate that it is not a different case mix of patients presenting to EDs that accounts for these between-hospital differences, but rather site-level characteristics (including teaching status and volume of AF patients seen).

Another way to put the hospital-level variation in BB versus CCB use into perspective with patient-level characteristics is through the median OR, which was 1.64 after adjusting for patient characteristics. When comparing the magnitude of the median OR (or its reciprocal, 0.61) to the ORs for the 23 patient-level variables, we note that the median OR is larger than the OR for 87% of the patient characteristics. Thus, the magnitude of the general contextual effect on choice of agent is stronger than that of 87% of the patient characteristics. The magnitude of the median OR was approximately the same as the magnitude of the effect of history of heart failure. Therefore, in half of all possible pairwise comparisons, the magnitude of the effect of ED on choice of agent was at least as large as the effect of history of heart failure.

The frequency of complications in our study was very low (2.4%), and all were managed with standard measures. This is similar to the findings of another ED study, where all of the 3.8% complication rate were hypotension and managed with a fluid bolus.[12] Unlike in that study, we found that in propensity score–matched groups (none of whom received a rhythm control strategy, which is the predominant emergency management approach in the United States[3]), the odds of admission were higher in patients who were given a CCB for rate control. While we note that physicians were more likely to choose a CCB in the presence of a higher presenting heart rate (which could contribute to the lower success rates in the CCB cohort), propensity score matching *included* matching on presenting heart rate, and despite this we still found that admission was more likely in the CCB cohort. In that study of 259 patients at two sites, they found no difference in the admission rate between groups (31% for patients receiving a CCB, 27% for a BB), nor for ED LOS; however, lack of adjustment and a small sample size limited study

Table 4
Propensity Score–matched Groups, by Receipt of a BB or a CCB (Patients Who Had an Attempted Cardioversion Excluded)

		Before Matching			After Matching		
Characteristic	Either CCB or BB, *n* = 1,080 (%)	CCB, *n* = 780 (%)	BB, *n* = 300 (%)	Std Diff	CCB, *n* = 249 (%)	BB, *n* = 249 (%)	Std Diff
Demographics							
Age (y), median (IQR)	74.0 (61.0–81.0)	74.0 (61.0–82.0)	73.0 (62.0–80.5)	0.0206	74.0 (61.0–82.0)	72.0 (62.0–80.0)	0.0263
Female	576 (53.3)	421 (54.0)	155 (51.7)	0.0462	132 (53.0)	131 (52.6)	0.008
Income quintile (5 = highest)							
1	206 (19.1)	164 (21.0)	42 (14.0)	0.1856	34 (13.7)	33 (13.3)	0.0118
2	222 (20.6)	155 (19.9)	67 (22.3)	0.0604	52 (20.9)	53 (21.3)	0.0098
3	196 (18.1)	141 (18.1)	55 (18.3)	0.066	46 (18.5)	48 (19.3)	0.0205
4	215 (19.9)	149 (19.1)	66 (22.0)	0.0718	57 (22.9)	56 (22.5)	0.0096
5	241 (22.3)	171 (21.9)	70 (23.3)	0.0337	60 (24.1)	59 (23.7)	0.0094
Rural	24 (2.2)	17 (2.2)	7 (2.3)	0.0104	6 (2.4)	7 (2.8)	0.0252
Came from							
Home	991 (91.8)	728 (93.3)	263 (87.7)	0.1942	226 (90.8)	223 (89.6)	0.0405
LTC facility	44 (4.1)	29 (3.7)	15 (5.0)	0.0628	9 (3.6)	10 (4.0)	0.021
Other†	45 (4.2)	23 (2.9)	22 (7.3)	0.1995	14 (5.6)	16 (6.4)	0.0338
Past medical history							
Atrial fibrillation	491 (45.5)	358 (45.9)	133 (44.3)	0.0314	101 (40.6)	106 (42.6)	0.0408
Stroke or TIA	72 (6.7)	44 (5.6)	28 (9.3)	0.1406	17 (6.8)	17 (6.8)	0
Diabetes mellitus	187 (17.3)	130 (16.7)	57 (19.0)	0.061	48 (19.3)	46 (18.5)	0.0205
Hypertension	614 (56.9)	439 (56.3)	175 (58.3)	0.0415	141 (56.6)	140 (56.2)	0.0081
CHA_2DS_2-VASc score ≥ 2	812 (75.2)	587 (75.3)	225 (75.0)	0.059	188 (75.5)	183 (73.5)	0.0461
HAS-BLED[35] ≥ 3	281 (26.0)	198 (25.4)	83 (27.7)	0.0517	73 (29.3)	64 (25.7)	0.081
Acute myocardial infarction	111 (10.3)	75 (9.6)	36 (12.0)	0.0769	22 (8.8)	30 (12.0)	0.1052
COPD	83 (7.7)	69 (8.8)	14 (4.7)	0.1671	15 (6.0)	14 (5.6)	0.0171
Chronic renal failure	53 (4.9)	34 (4.4)	19 (6.3)	0.0879	12 (4.8)	14 (5.6)	0.0361
Cancer‡	120 (11.1)	87 (11.2)	33 (11.0)	0.049	30 (12.0)	29 (11.6)	0.0124
Dementia	57 (5.3)	41 (5.3)	16 (5.3)	0.034	15 (6.0)	11 (4.4)	0.0723
ADG score, median (IQR)	10.0 (7.0–13.0)	10.0 (7.0–13.0)	11.0 (8.0–14.0)	0.1748	11.0 (7.0–13.0)	10.0 (7.0–13.0)	0.0547
Medications prior to ED visit (*patients may be in more than one group*)							
Warfarin	264 (24.4)	197 (25.3)	67 (22.3)	0.0687	52 (20.9)	57 (22.9)	0.0486
BB	340 (31.5)	197 (25.3)	143 (47.7)	0.4788	102 (41.0)	100 (40.2)	0.0164
CCB	114 (10.6)	106 (13.6)	8 (2.7)	0.408	9 (3.6)	8 (3.2)	0.0221
Digoxin	68 (6.3)	55 (7.1)	13 (4.3)	0.1175	11 (4.4)	11 (4.4)	0
Antiarrhythmic	92 (8.5)	70 (9.0)	22 (7.3)	0.06	16 (6.4)	19 (7.6)	0.0471
ED visit							
Hospital type							
Teaching	303 (28.1)	179 (22.9)	124 (41.3)	0.4015	86 (34.5)	86 (34.5)	
Community	777 (71.9)	601 (77.1)	176 (58.7)		163 (65.5)	163 (65.5)	

(Continued)

Table 4 (continued)

Characteristic	Either CCB or BB, *n* = 1,080 (%)	Before Matching			After Matching		
		CCB, *n* = 780 (%)	BB, *n* = 300 (%)	Std Diff	CCB, *n* = 249 (%)	BB, *n* = 249 (%)	Std Diff
Presenting vital signs, median (IQR)							
Heart rate	127.0 (108.0–145.0)	130.0 (111.5–148.0)	119.50 (99.5–136.0)	0.412	122.0 (105.0–140.0)	120.0 (100.0–140.0)	0.0688
Systolic BP	133.0 (119.0–150.0)	133.5 (119.5–150.0)	133.0 (116.5–150.0)	0.0199	131.0 (117.0–148.0)	133.0 (116.0–150.0)	0.0259
ED triage group (1 highest acuity)							
1, 2	854 (79.1)	631 (80.9)	223 (74.3)	0.158	190 (76.3)	190 (76.3)	0
3, 4, 5	226 (20.9)	149 (19.1)	77 (25.7)		59 (23.7)	59 (23.7)	0
Arrival by ambulance	368 (34.1)	282 (36.2)	86 (28.7)	0.1605	78 (31.3)	73 (29.3)	0.0437
Initial ECG							
Ischemic changes	307 (28.4)	219 (28.1)	88 (29.3)	0.0278	75 (30.1)	71 (28.5)	0.0353
Wide QRS (>120 mm)	106 (9.8)	73 (9.4)	33 (11.0)	0.0543	22 (8.8)	25 (10.0)	0.0412
Chest x-ray shows pulmonary edema	129 (11.9)	110 (14.1)	19 (6.3)	0.2586	17 (6.8)	18 (7.2)	0.0157
Evidence of heart failure§	320 (29.6)	258 (33.1)	62 (20.7)	0.2827	49 (19.7)	52 (20.9)	0.03
Furosemide given in ED	125 (11.6)	110 (14.1)	15 (5.0)	0.3135	9 (3.6)	15 (6.0)	0.1127
Laboratory measures							
Positive troponin (conventional)	120 (11.1)	87 (11.2)	33 (11.0)	0.049	33 (13.3)	32 (12.9)	0.0119
Creatinine > 200 mmol/L (2.26 mg/dL)	23 (2.1)	15 (1.9)	8 (2.7)	0.0497	*	*	0.0273
INR level							
<2	809 (74.9)	596 (76.4)	213 (71.0)	0.1231	177 (71.1)	175 (70.3)	0.0355
2–3	130 (12.0)	86 (11.0)	44 (14.7)	0.109	33 (13.3)	37 (14.9)	0.0467
>3	58 (5.4)	47 (6.0)	11 (3.7)	0.11	11 (4.4)	11 (4.4)	0.0191
Not done	83 (7.7)	51 (6.5)	32 (10.7)	0.1476	28 (11.2)	26 (10.4)	0.0132
Disposition details							
Final ED rhythm							
AF	604 (55.9)	423 (54.2)	181 (60.3)	0.1236	146 (58.6)	147 (59.0)	0.0082
Normal sinus	413 (38.2)	310 (39.7)	103 (34.3)	0.1122	90 (36.1)	89 (35.7)	0.0084
Other	63 (5.8)	47 (6.0)	16 (5.3)	0.0299	13 (5.2)	13 (5.2)	0
ED LOS (minutes), median (range)	7.8 (4.9–16.2)	8.1 (5.0–16.9)	7.4 (4.7–13.9)	0.086	7.3 (4.9–13.7)	7.4 (4.6–13.2)	0.0211

ADG = adjusted diagnosis group; BB = beta-blocker; BP = blood pressure; CCB = calcium channel-blocker; COPD = chronic obstructive pulmonary disease; ECG = electrocardiogram; INR = international normalized ratio; IQR = interquartile range; LTC = long-term care; Std Diff = standardized difference; TIA = transient ischemic attack.
*Small cell size (≤5 patients), not reported as per privacy agreement with the Canadian Institutes of Health Information (CIHI).
†Large majority were sent from a physician's office.
‡Includes major cancers (basal cell and squamous cell cancers of the skin were excluded).
§Includes a past medical history of heart failure, a history and physical examination findings consistent with heart failure, evidence on chest x-ray, or administration of furosemide in the ED.

conclusions.[12] In our matched patients from over 20 sites, we also found no difference in median ED LOS (5 minutes) by medication class.

A systematic review of studies published between 1965 and 2014 on the efficacy of rate control agents in the ED setting included only two studies (one an abstract) that provided enough information to allow the calculation of a relative risk (RR).[10] The full study was a randomized controlled trial (RCT) that excluded patients with chronic obstructive pulmonary disease (COPD) and those who were on a rate control agent in the 5 days prior to presentation, while the abstract was also an RCT but did not provide details on inclusion criteria. With the combined data on 92 patients, the authors found that 65% of the patients who received IV diltiazem achieved a ventricular rate of <100 beats/min within 20 minutes of administration versus 50% who received IV metoprolol (RR = 1.80; 95% CI = 1.23–2.62). A single-site RCT of 52 patients had similar findings, albeit with higher reported success rates with IV diltiazem (96%).[11] None of these small studies assessed outcomes after the first 30 minutes following IV medication administration, which limits their clinical utility (in terms of informing disposition decisions). The results are in contrast to those of our study, which found that admissions were higher in the matched CCB group; admissions were likely due to unsuccessful rate control,[12] as the other obvious reasons for admission (myocardial infarction, heart failure, high thromboembolic risk)[5] were balanced between the our propensity score–matched groups (furosemide given in the ED was actually slightly lower in the matched CCB group, as was history of acute myocardial infarction). Another important explanation for the differing results could be that while the heart rate initially slows more using IV diltiazem, the administration of follow-up oral medication is not as effective (due to either insufficient dose or delays in administration) at maintaining rate control. Indeed, in our study the time to administration of oral diltiazem following IV diltiazem was a median 51 minutes longer than time between IV and oral metoprolol.

LIMITATIONS

The observational nature of the data is subject to selection bias. We used propensity score matching on a myriad of patient- and site-level variables to adjust for this, including presenting heart rate, so the lower initial heart rate in the BB group was removed among the matched groups. However, propensity score matching cannot account for unmeasured covariates; only an RCT can do this. Because the data were collected from patient charts, some data were missing, including success rates for 30 of the 385 patients who received metoprolol. If all of these cases were successful, the metoprolol success rate would increase from 71.4% to 79.2% and the BB success rate from 70.9% to 78.1%; however, this does not change the direction of our results. Our study did not examine the reasons for admission, which can include social factors[33] as well as the medical factors noted in guidelines;[5] however, we matched on income quintile, rural residence, and ADG risk score, which should capture some of these social factors.

We restricted our patient population to those with a primary ED diagnosis of AF because patients with a different primary ED diagnosis (who also have AF) have a markedly different prognosis (1-year mortality rate greater than twice as high).[14,34] However, the use of CCBs versus BBs might be quite different in patients who present to the ED with active COPD or heart failure; our results may not apply to that patient cohort. Our data are from 2009; however, there have been no new rate control medications introduced since that time, nor major changes to the rate control management of AF patients.

CONCLUSIONS

Calcium channel blockers were used more often than beta-blockers for ED rate control. There was substantial variation between EDs, with more teaching sites using beta-blockers than community sites; however, the variation was not as high as might be expected given that guidelines do not recommend one agent over the other. Among 23 patient-level characteristics examined, there were relatively few predictors of beta-blocker versus calcium channel blocker use, suggesting that practice patterns are not strongly entrenched. In matched ED patients who were not undergoing a rhythm control strategy, administration of a beta-blocker was associated with lower hospital admissions compared to a calcium channel blocker, but no difference in ED length of stay.

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Supporting Information

The following supporting information is available in the online version of this paper available at http://onlinelibrary.wiley.com/doi/10.1111/acem.13303/full

Data Supplement S1. Hierarchical logistic modelling results, intraclass correlation coefficient, and median OR.