Impact of a Practice Guideline for Patients With Atrial Fibrillation on Medical Resource Utilization and Costs

Peter Zimetbaum, MD, Matthew R. Reynolds, MD, MSc, Kalon K.L. Ho, MD, MSc, Thomas Gaziano, MD, MSc, Mary Jane McDonald, RN, MS, Seth McClennen, MD, Ronna Berezin, MPH, Mark E. Josephson, MD, and David J. Cohen, MD, MSc

Health care resource utilization is high for patients presenting with acute atrial fibrillation (AF). The potential for treatment algorithms to safely reduce resource consumption in this setting has not been prospectively evaluated. We designed and implemented a practice guideline for the management of patients presenting to the emergency department (ED) with the primary diagnosis of AF, with emphasis on appropriate cardioversion, use of oral rate-controlling medications, and expedited referral to an outpatient AF clinic. We prospectively collected clinical and resource utilization data on all such patients for 14 months before and after institution of the guideline. Institution of the guideline was associated with a decreased rate of hospital admission (from 74% to 38%), with no differences in ED return visits or hospital readmission within 30 days. No strokes or deaths were observed. This large decrease in resource utilization during the intervention phase of the study translated to an average decrease in 30-day total direct health care costs of approximately $1,400 per patient. Our clinical and cost outcomes were minimally affected after statistical adjustment for baseline differences between study groups. We conclude that the implementation of our practice guideline was feasible, safe, and effective. Widespread adoption of such practices may have large financial implications for the health care system.

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There are few data to direct appropriate management of patients who present to the emergency department (ED) with atrial fibrillation (AF). Previous studies by our group and others suggest that many patients with AF are admitted for questionable indications (e.g., to "rule out myocardial infarction") or for therapeutic interventions that could readily be accomplished in the outpatient setting.[1–3] Nonetheless, national survey data indicate that 65% to 70% of all ED visits for a principal diagnosis of AF result in hospital admission.[4] We hypothesized that standardizing the criteria for hospital admission and safely facilitating the outpatient management of patients could prevent unnecessary hospital admissions and reduce health care expenditures without adversely affecting patient outcomes. To evaluate the impact of such an approach, we devised and tested a clinical algorithm for the ED management of patients presenting with AF.

METHODS

Patient population and data collection: The present study was performed in 2 intervals consisting of an observational "preintervention" phase (January 1998 to February 1999) and a subsequent "intervention" phase (March 1999 to April 2000). During both phases, we prospectively followed all patients presenting to the ED of the Beth Israel Deaconess Medical Center with the primary diagnosis of AF. Patients were excluded if they had another reason in addition to AF that required emergency care. The same patient could be used as a study subject more than once provided that consecutive ED visits were ≥30 days apart. A trained research nurse collected demographic and clinical data, including baseline patient characteristics; treatments performed in the ED; patient disposition; reason(s) for admission as identified by the primary treating physician; and clinical course once admitted. The study protocol was approved by the Beth Israel Deaconess Medical Center Committee on Clinical Investigations.

Institution of practice guideline intervention: The intervention phase of the study involved the implementation of a detailed practice guideline in the ED designed to standardize the management of patients with AF. The fundamental components of the guideline included utilization of oral rate-controlling medications, standard criteria for cardioversion in the ED, and the availability of rapid (within 48 hours) follow-up in a dedicated AF clinic (Figure 1).

Educational presentations that reviewed the key principles of the practice guideline were delivered to primary care physicians and at medical and ED house staff educational conferences. Specific emphasis was placed on the criteria for cardioversion, exclusion of myocardial ischemia, and the administration of oral rate-controlling agents. To serve as a reminder, the guideline was placed in the charts of all patients with

From Beth Israel Deaconess Medical Center, Harvard Clinical Research Institute, and Brigham and Women's Hospital, Harvard Medical School, Boston, Massachusetts. Manuscript received March 5, 2003; revised manuscript received and accepted June 2, 2003.

Address for reprints: Peter Zimetbaum, MD, Division of Cardiology, Beth Israel Deaconess Medical Center, One Deaconess Road, Boston, Massachusetts 02215. E-mail: pzimetba@caregroup.harvard.edu.

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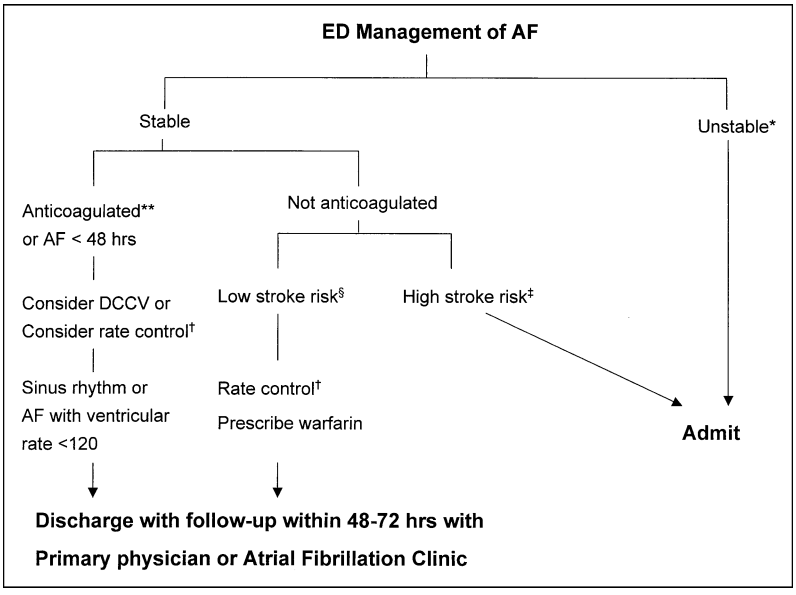

FIGURE 1. Management algorithm for patients presenting to the ED with the primary diagnosis of AF. *Presence of congestive heart failure, hypotension, or myocardial ischemia/infarction. †Preference for oral β blocker or calcium channel blocker to be administered alone or at the same time as intravenous β blockade or calcium channel blockade. ‡Prior stroke/TIA, rheumatic disease, or congestive heart failure. §Absence of high-risk features. **INR >2.0 for at least 3 consecutive weeks. DCCV = electrical cardioversion performed in the ED.

AF in the ED. In addition, quarterly reminders were broadcast through electronic mail regarding key components of the guideline.

Follow-up: In both phases of the study, 30-day follow-up data, including documentation of subsequent hospital admissions, ED and outpatient visits, cardioversion, and cardiac noninvasive testing, were acquired through chart review and telephone contact.

Determination of medical care costs: We determined health care costs for each patient using "bottom up" accounting methods.[5] For each study subject, we measured medical resource utilization for the initial hospital visit and 30-day follow-up period. For each hospitalization, we collected data regarding length of stay, cardiac diagnostic studies (e.g., transthoracic and transesophageal echocardiography, diagnostic catheterization), and therapeutic interventions (e.g., cardioversion, pacemaker implantation, coronary revascularization). We also collected data on the use of outpatient services, including visits to primary care physicians and cardiologists and outpatient diagnostic and therapeutic procedures within 30 days of the index ED visit.

Unit costs: Unit costs for hospital-based diagnostic and therapeutic procedures, ancillary services, room, and nursing services were estimated based on the microcost accounting system (Transition Systems, Inc., Boston, Massachusetts) of Beth Israel Deaconess Medical Center. Costs for outpatient services, including office visits and diagnostic testing, as well as physician fees for in-patient and outpatient services, were estimated from the Medicare Fee Schedule for Massachusetts. Cumulative 30-day medical care costs were determined by multiplying each resource utilization measure by the appropriate unit cost. All costs are expressed in 1999 U.S. dollars.

Risk adjustment of costs: To assess the robustness of our findings, we adjusted our cost comparisons for potential confounding clinical factors that differed between study phases. Total 30-day costs were divided into 3 time periods (emergency room, in-patient, and follow-up). Separate linear regression models incorporating baseline demographic and clinical variables were constructed to risk-adjust costs for each of the 3 periods. In addition, the probabilities of ED cardioversion (a critical determinant of ED cost) and hospital admission were modeled using multivariate logistic regression. We then used Monte Carlo simulation[6] to estimate cumulative costs for each study phase based on the risk-adjusted cost estimates for emergency room, in-patient and follow-up care, and the risk-adjusted probabilities of admission and cardioversion. For comparative purposes, 3 groups of patients were modeled (patients aged 75 vs 50 years, patients with and without congestive heart failure, and patients with and without diabetes mellitus).

Statistical analysis: Discrete data are presented as frequencies, whereas continuous data are presented as mean $\pm$ 1 SD. In addition, median values are reported for cost outcomes (to reflect the cost of a "typical" subject). Continuous variables were compared by *t* tests and categoric variables by the chi-square statistic or Fisher's exact test. Statistical significance was defined by a 2-tailed p value of <0.05. All analyses were performed using SAS version 6.12 (SAS Institute, Cary, North Carolina) and DATA 4.0 software (TreeAge Software, Williamstown, Massachusetts).

RESULTS

Patient population: Four hundred forty-six subjects were enrolled in the study (264 in the preintervention phase and 182 in the intervention phase). Baseline characteristics of the study population are listed in Table 1. Compared with the preintervention phase, patients in the intervention phase of the study were slightly younger, less often hypertensive, and less likely to present with congestive heart failure symptoms. Patients in the intervention phase were also more likely to complain of palpitations and were slightly more likely to have established paroxysmal AF.

ED management: Key elements of clinical management in the ED are shown in Figure 2. As directed by the practice guideline, the intervention phase of the study was associated with a significant increase in the performance of electrical cardioversion and adminis-

TABLE 1 Baseline Characteristics of the Study Groups

	Preintervention (n = 264)	Intervention (n = 182)	p Value
Baseline characteristics			
Age (yrs)	70 ± 16	66 ± 16	0.01
Women	132 (50%)	98 (54%)	0.42
Systemic hypertension	156 (59%)	84 (46%)	0.006
Diabetes mellitus	40 (15%)	35 (19%)	0.09
Coronary artery disease	63 (24%)	31 (17%)	0.08
Congestive heart failure	32 (12%)	18 (10%)	0.53
Medications at baseline			
Calcium antagonist or β blocker	145 (55%)	73 (40%)	0.003
Digoxin	37 (14%)	27 (15%)	0.61
Symptoms at presentation			
Ventricular rate (beats/min)	118 ± 29	120 ± 30	0.35
Congestive heart failure	26 (10%)	7 (4%)	0.02
Chest pain	66 (25%)	42 (23%)	0.71
Dyspnea	111 (42%)	64 (35%)	0.12
Palpitations	148 (56%)	124 (68%)	0.01
No symptoms	34 (13%)	24 (13%)	0.98
AF history			0.03
New atrial fibrillation	100 (38%)	62 (34%)	
Paroxysmal atrial fibrillation	148 (56%)	116 (64%)	
Chronic atrial fibrillation	16 (6%)	4 (2%)	

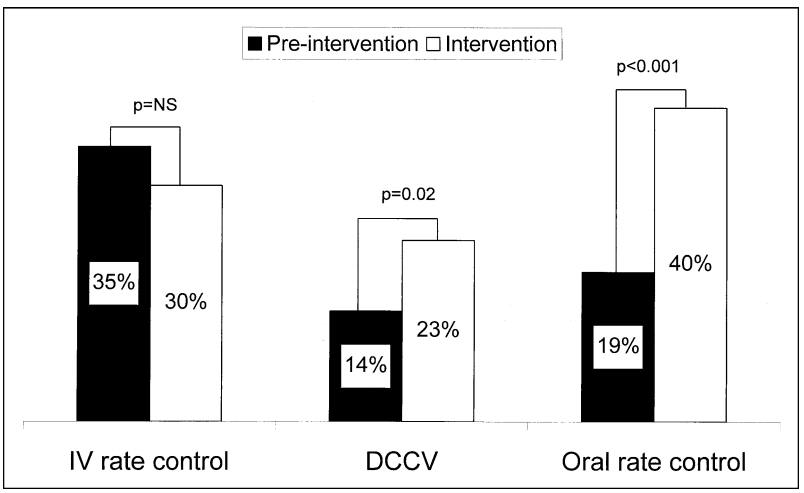

FIGURE 2. Selected components of ED management by study phase. IV = intravenous; other abbreviation as in Figure 1.

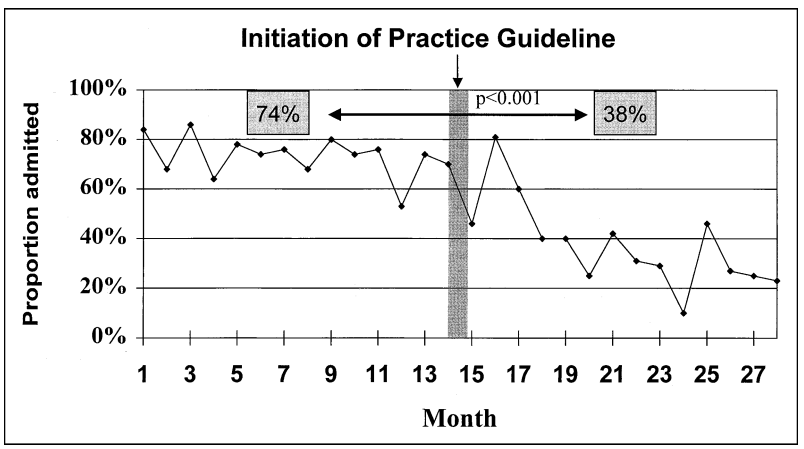

FIGURE 3. Proportion of ED patients with AF as their primary diagnosis admitted to the hospital each month. The *vertical gray bar* denotes the month the practice guideline was initiated.

tration of oral rate controlling agents in the ED, compared with the preintervention phase. Implementation of the practice guideline was associated with a 49% decrease in the probability of hospital admission, from 74% to 38% ($p < 0.0001$; Figure 3).

Reasons for hospital admission: During the preintervention phase, the most common reasons for hospital admission cited by the primary treating physicians included performance of a "rule out myocardial infarction" protocol, rate control, anticoagulation, and cardioversion (Table 2). Compared with the preintervention phase, physicians in the intervention phase were less likely to list cardioversion as a reason for hospital admission but significantly more likely to cite patient preference.

A multivariable logistic regression model incorporating baseline patient characteristics and symptoms at ED presentation found age >65 years and chest pain and shortness of breath symptoms to be predictors of hospital admission (Table 3). Patients with congestive heart failure symptoms at presentation showed a nonsignificant trend favoring admission. The only factors found to predict against hospital admission were palpitations at presentation and, most strongly, the intervention phase of the study.

Management of hospitalized patients: In addition to the significant decrease in the likelihood of hospitalization from the preintervention to the intervention phase, the intensity of in-patient resource utilization among patients, once hopitalized, declined between study phases as well. Transthoracic echocardiography (36% vs 28%), transesophageal echocardiography (16% vs 8%), and electrical cardioversion (62% vs 50%) were each performed in a greater proportion of hospitalized patients during the preintervention phase than in the postintervention phase ($p < 0.05$ for all comparisons). Once admitted, similar proportions of patients underwent "rule-out" protocols (119 of 195 patients [61%] vs 42 of 70 patients [60%]; p = NS), thus the total number of rule-out protocols performed was much smaller during the intervention phase because far fewer patients were admitted. Despite these differences in resource intensity, length of stay was

TABLE 2 Reasons Cited for Hospitalization Among Admitted Patients in Each Study Phase

Reason Cited for Admission*	Preintervention (n = 195)	Intervention (n = 70)	p Value
Rule-out protocol	100 (51%)	28 (40%)	0.11
Anticoagulation	71 (36%)	21 (30%)	0.33
Rate control	99 (51%)	36 (51%)	0.93
Cardioversion	72 (37%)	17 (24%)	0.06
Antiarrhythmic drug initiation	18 (9%)	5 (7%)	0.600
Patient preference	11 (6%)	24 (34%)	0.001

*More than 1 reason per patient could be given, thus column sums are more than 100%. Proportions are the frequency of a cited item divided by the number of patients admitted.

TABLE 3 Multivariate Predictors of Hospital Admission

Variable	Odds Ratio	95% CI	p Value
Congestive heart failure	3.3	0.9–12.2	0.07
Chest pain	2.8	1.6–5.0	0.0004
Age >65 yrs	2.0	1.2–3.4	0.01
Dyspnea	1.7	1.0–2.7	0.04
Palpitations	0.4	0.3–0.7	0.002
Intervention phase	0.2	0.1–0.4	0.0001

CI = confidence interval.

TABLE 4 Resource Utilization (per 100 patients)

	Preintervention (n = 264)	Intervention (n = 182)	p Value
Hospital care			
Admissions	74	38	0.001
Hospital days	206	97	—
Rule-out protocols	45	23	0.001
Transthoracic echos	27	11	0.001
Transesophageal echos	12	3	0.001
Stress tests	3	2	NS
Cardiac catheterizations	1	0	NS
ED cardioversions	14	23	0.02
In-patient cardioversions	46	19	0.001
Follow-up care			
ED visits	8	9	NS
Office visits			
Primary care	53	60	—
General cardiology	20	21	—
Electrophysiology	14	30	—
Repeat admissions	5	3	NS
(total in-patient days)	(19)	(10)	—
Transthoracic echos	9	17	0.02
Outpatient cardioversions	2	5	NS
Transesophageal echos	1	2	NS
Event monitors	8	13	0.07
Stress tests	1	1	NS

Values in rows with p values are expressed as proportions, values in rows without p values are expressed as total numbers.

roughly the same for admitted patients in each phase (2.5 ± 2.2 vs 2.8 ± 2.2 days, p = NS).

Follow-up outcomes: Over the 30 days after the index ED visit, the frequency of repeat emergency room visits and hospital admissions was similar for the 2 study phases (Table 4), whereas the number of visits to primary care physicians and electrophysiologists increased during the intervention phase. As expected, the use of outpatient diagnostic procedures increased during the intervention phase as well. No strokes or deaths were observed during follow-up in either study phase.

Resource utilization and costs: Total resource utilization (per 100 patients) for the 2 study phases is listed in Table 4. Hospital-based resource utilization significantly decreased during the intervention phase of the study. In keeping with the practice guideline, ED cardioversions, follow-up visits to primary care physicians and electrophysiologists, and outpatient diagnostic tests occurred more frequently during the intervention phase.

The results of our cost analysis are shown in Figure 4. During the intervention phase, we observed an average decrease in in-patient costs of about $1,500 per patient (95% confidence interval $1,010–$1,944, p <0.001). As expected, emergency room costs increased modestly during the intervention phase, but 30-day follow-up costs were roughly equal because greater utilization of outpatient resources in the intervention phase was offset by a decrease in follow-up hospital days. Thus, average total 30-day health care costs were reduced by about $1,400 per subject (95% confidence interval $883–$1,891, p <0.0001).

Table 5 lists risk-adjusted 30-day mean costs in the preintervention and intervention phases for "typical" patients stratified by age, presence of congestive heart failure, and diabetes mellitus, as determined by Monte Carlo simulation. Although 30-day costs varied by as much as $2,000 for patients with or without certain characteristics (e.g., congestive heart failure), for each comparison, mean cost was significantly lower for the intervention phase than for the preintervention phase. The difference in mean costs ranged from $1,037 to $1,434.

DISCUSSION

Our study demonstrates the feasibility of an ED practice guideline designed to reduce the rate of hospital admission for patients with AF. We report a 49% decrease in hospital admission frequency and a 35% decrease in aggregate 30-day health care costs with no increase in adverse events, ED return visits, or hospital readmissions. These findings were minimally affected by adjustment for modest imbalances in baseline characteristics. If cost reductions of this magnitude were replicated and extrapolated to the entire U.S. health care system (>300,000 annual ED visits for AF[4]) annual total cost savings could approach 3 to 4 hundred million dollars.

The key interventions stressed by the practice guideline were appropriate performance of electrical cardioversion in the ED and the increased utilization of oral rate-controlling medications. Improved familiarity with the indications for and practice of electrical cardioversion in the ED led to a marked decrease in the number of patients admitted for in-hospital cardio-

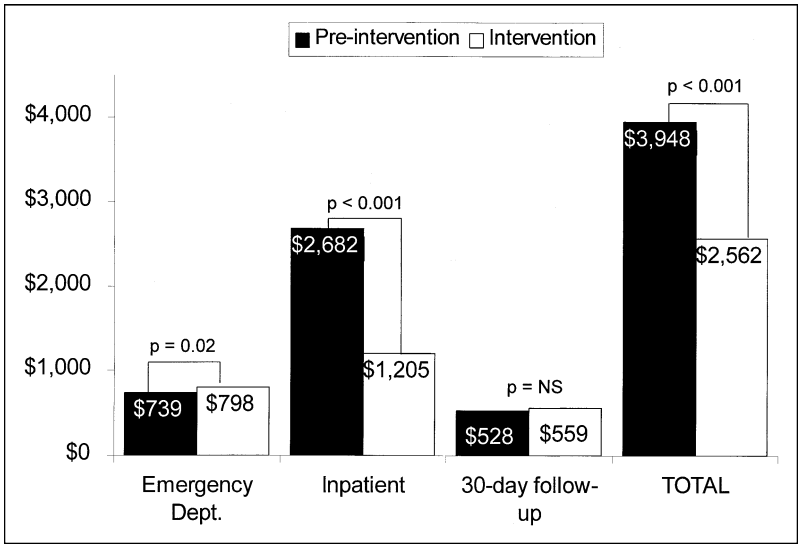

FIGURE 4. Mean per-patient costs for the index ED visit, initial hospital stay, 30-day follow-up, and total, by study phase. Total costs were $1,400/patient lower during the intervention phase.

TABLE 5 Risk-adjusted 30-day Costs According to Clinical Characteristics

Characteristic	Risk-adjusted Costs*		Cost Difference (95% CI)
	Preintervention	Intervention	
Age 75 years	3,697	2,643	1,054 (688–1,362)
Age 50 years	3,316	2,143	1,172 (690–1,552)
Congestive heart failure	5,441	4,404	1,037 (539–1,463)
No congestive heart failure	3,427	2,344	1,082 (688–1,456)
Diabetes mellitus	4,468	3,034	1,434 (1003–1,931)
No diabetes mellitus	3,413	2,368	1,044 (666–1,372)

*Costs expressed in 1999 U.S. dollars.
Abbreviation as in Table 3.

version (29% [72 of 295 patients] in the preintervention phase vs 9% [17 of 182 patients] in the intervention phase). The increased use of oral rate-controlling agents also appeared to facilitate the discharge of patients from the ED.

A critical factor in the success of our intervention was the provision of prompt and effective outpatient subspecialty consultation for patients with AF. By raising awareness of the availability of this service at our center, implementation of the practice guideline appeared to have an impact not only on the management and disposition of patients with AF seen in the ED, but also in the referral of patients to the ED in the first place. A notable decrease in the number of ED visits for AF (from 19 to 13 per month) occurred between study phases despite a small increase in total ED visits during the same time frame. This coincided with an increase in the number of new patient visits (from 19 to 30 per month) to the Beth Israel Deaconess AF Clinic. This suggests that in some instances physicians referred patients directly to the AF clinic rather than to the ED. If the intervention actually did prevent ED visits, then the overall impact of the practice guideline in reducing resource utilization and costs may have been underestimated because subjects were enrolled only after presenting to the ED. Of course, the costs of providing outpatient subspecialty care for patients with AF would have to be considered at centers where such resources are not readily available.

We are unaware of any previous studies comparable with ours that have carefully measured the costs of treating patients with AF or the effects of an AF practice guideline. The only previous studies that reported economic data on patients with AF either evaluated charges rather than costs[2] or relied on modeling rather than measured data.[7] A pilot study of a randomized intervention for ED management was recently published but managed to enroll only 18 subjects.[8]

The clinical characteristics and management practices seen in the preintervention phase of our study were consistent with earlier observational studies[1,2] and recent national survey data,[4] although the average length of stay in our cohort (2.8 days) was shorter than previously reported. Based on data from the preintervention phase of this study, we previously confirmed the findings of other investigators[1] that acute myocardial infarction is relatively uncommon (~2%) in this patient population, and showed that it is virtually always accompanied by major ST-segment deviations on electrocardiography.[3] Thus, the need to admit and rule out myocardial infarction in patients with recent-onset AF appears grossly overestimated by many practitioners.

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