Application of a Decision Support Tool for Anticoagulation in Patients with Non-valvular Atrial Fibrillation

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BACKGROUND: Atrial fibrillation affects more than two million Americans and results in a fivefold increased rate of embolic strokes. The efficacy of adjusted dose warfarin is well documented, yet many patients are not receiving treatment consistent with guidelines. The use of a patient-specific computerized decision support tool may aid in closing the knowledge gap regarding the best treatment for a patient.

METHODS: This retrospective, observational cohort analysis of 6,123 Ohio Medicaid patients used a patient-specific computerized decision support tool that automated the complex risk–benefit analysis for anticoagulation. Adverse outcomes included acute stroke, major gastrointestinal bleeding, and intracranial hemorrhage. Cox proportional hazards models were developed to compare the group of patients who received warfarin treatment with those who did not receive warfarin treatment, stratified by the decision support tool's recommendation.

RESULTS: Our decision support tool recommended warfarin for 3,008 patients (49%); however, only 9.9% received warfarin. In patients for whom anticoagulation was recommended by the decision support tool, there was a trend towards a decreased hazard for stroke with actual warfarin treatment (hazard ratio 0.90) without significant increase in gastrointestinal hemorrhage (0.87). In contrast, in patients for whom the tool recommended no anticoagulation, receipt of warfarin was associated with statistically significant increased hazard of gastrointestinal bleeding (1.54, p=0.03).

CONCLUSIONS: We have shown that our atrial fibrillation decision support tool is a useful predictor of those at risk of major bleeding for whom anticoagulation may not necessarily be beneficial. It may aid in weighing the benefits versus risks of anticoagulation treatment.

KEY WORDS: atrial fibrillation; decision support; anticoagulation; decision aid.
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INTRODUCTION

Atrial fibrillation is the most prevalent serious cardiac arrhythmia and is a significant risk factor for stroke.[1,2] If left untreated, these patients face a significant fivefold increased rate of embolic stroke, and the risk is greatest in the elderly.[3] Numerous clinical trials have demonstrated the efficacy of anticoagulation therapy to significantly reduce this risk of thromboembolism and the devastating outcome of ischemic stroke in patients with atrial fibrillation.[4–11] Two studies have shown that more than 50% of patients without contraindications to anticoagulation therapy are receiving warfarin, but other studies have documented substantially fewer patients receiving treatment consistent with guidelines.[12–20] The challenge is to identify those patients for whom the benefit from treatment outweighs the risk.

Patient-specific characteristics known at the time of decision making substantially alter the patient's risk of both ischemic stroke and hemorrhage with anticoagulation.[1,21–24] Published anticoagulation guidelines are limited in their ability to consider the individual patient's balance of risk and benefit, especially when the risk of hemorrhage is increased.[25,26] Other patient- and physician-related factors might contribute to a decision to withhold warfarin. For example, physicians are less likely to use anticoagulation in older patients, but it is this population that has the greatest risk of stroke, and thus, the greatest opportunity to benefit from intervention.[27–29]

Given the efficacy of adjusted dose warfarin in reducing the risk of ischemic stroke by 68%, patient-specific computerized decision support may aid in closing the known gap between knowledge and optimal treatment for a patient.[1,30,31] Our goal was to validate the ability of an Atrial Fibrillation Decision Support Tool to identify those who would benefit or be harmed from anticoagulation therapy to prevent thromboembolic events in a cohort of Ohio Medicaid patients with nonvalvular atrial fibrillation. Short of a randomized trial, this retrospective study was felt to be the best way to predict the performance of the tool. The methodology might be of use to test other tools. We hypothesized that patients receiving anticoagulation treatment concordant with the decision support tool recommendation would have fewer adverse events compared with discordant care.

RESEARCH DESIGN AND METHODS

Basic Design and Data Sources

This study was a retrospective, observational cohort analysis of Ohio Medicaid patients from January 1, 1997 through May 31, 2002. Data were collected from the Ohio Medicaid administrative claims database, which has been well described elsewhere,[19,32,33] and the Ohio Mortality Public Use Statistical file. Ohio Medicaid provides coverage for certain low-income and medically vulnerable residents; aged, blind, or disabled and covered families and children. It includes fee-for-service data from all institutions, providers, and pharmacies that provide services to Ohio Medicaid enrollees.

The identified Ohio Medicaid patients were then cross-matched with the Ohio Mortality Public Use Statistical file from January 1, 1998 through May 31, 2002. This file contains data from death certificates for any person who dies in Ohio and Ohio residents who die out of state.

Patient Selection

We identified all patients with two or more claims containing an *International Classification of Diseases, Ninth Revision, Clinical Modification* code (ICD-9-CM) for atrial fibrillation (427.31) during the study period. Two claims were required for inclusion to increase the likelihood of accurate atrial fibrillation diagnosis. We excluded all patients with lone atrial fibrillation, a history of valvular heart disease (two or more claims with ICD-9-CM codes for mitral valve disease, aortic valve disease, mitral and aortic valve disease, heart valve transplant, or heart valve replacement, or a procedure code for mitral or aortic valve repair or replacement). We included only those patients with 12 consecutive months of enrollment before the first atrial fibrillation diagnosis, which was considered incident atrial fibrillation for the purpose of this study. We followed patients for adverse events until the first month not enrolled in Medicaid; thus, patients were censored at disenrollment.

We used pharmacy claims data to exclude patients who filled prescriptions for warfarin before the initial atrial fibrillation diagnosis. Using the same pharmacy claims data, patients were considered to be treated with warfarin if they filled prescriptions for warfarin within 30 days of the atrial fibrillation diagnosis. Few patients were started on treatment or stopped treatment beyond this 30-day period.

Risk Factors

In the 12-month period before the incident atrial fibrillation diagnosis, we identified patient-specific factors known to influence the risk for stroke and the risk for hemorrhage, and we identified other factors that potentially influence the decision to prescribe warfarin. We used ICD-9-CM for inpatient and outpatient claims, and medication therapeutic class codes were used for pharmacy claims.

Demographic data were used to derive the age, gender, and race for each patient. We identified covariates known to influence the risk of stroke, which include age, hypertension, diabetes mellitus, congestive heart failure, prior stroke, and prior myocardial infarction.[1] We identified covariates known to influence the risk of hemorrhage, which include prior gastrointestinal hemorrhage, prior intracranial hemorrhage, anemia, and renal insufficiency.[34,35] Any stroke or myocardial infarction that occurred within the prior 90 days to incident atrial fibrillation diagnosis was considered a "recent" event.

We identified, a priori, other covariates that we believe to potentially influence warfarin prescribing but whose effects on stroke and bleeding risk are not quantified in the literature. Psychiatric illness includes schizophrenia, affective psychosis, paranoia, or other non-organic psychosis. Substance abuse includes alcohol dependence, drug dependence, or nondependent alcohol abuse (excluding tobacco use disorder). Social risk factors includes lack of housing, inadequate housing, inadequate material resources, persons living alone, no other household member able to render care, or noncompliance with medical treatment.

Concurrent medication use also may influence warfarin prescribing and risk for hemorrhage. Utilizing medication therapeutic class codes, we defined the categories of: gastrointestinal protection (antacids, anti-ulcer preparations, hemorrhoidal agents/preparations, rectal preparations, H2 inhibitors), analgesics (non-narcotic analgesics, salicylate analgesics, anti-inflammatory agents, non-steroidal anti-inflammatory drugs, miscellaneous analgesics), steroids/immunosuppressants (systemic glucocorticoids, mineralocorticoids, immunosuppressives), and other bleed risk (anti-hemophilic factors, heparin preparations, anti-neoplastics).

Decision Support Tool for Anticoagulation Recommendation

We have described previously a decision analytic tool that incorporates *patient-specific risks* for ischemic stroke and major bleeding events and calculates expected outcomes for patients with atrial fibrillation with and without warfarin treatment.[36–40] This tool is consistent with ACC/AHA/ESC 2006 guidelines. However, while guidelines explicitly address risk stratification for stroke, they provide little guidance on bleeding risk assessment.[26] Our tool explicitly accounts for the risk of bleeding and formally addresses the balance of risk of bleeding with the benefit of stroke prevention. This decision support tool is designed to individualize treatment recommendations based upon a patient's age, gender, and different degrees of risk for thromboembolism and hemorrhage by predicting quality-adjusted life years (QALYs).[38–40] Other patient-specific variables used to determine a patient's risk included a history of diabetes mellitus, hypertension, congestive heart failure, myocardial infarction, prior stroke/TIA, gastrointestinal bleed, anemia, and renal insufficiency. The embedded risk prediction models derived from the medical literature are used to estimate the annual rate of ischemic stroke[1] and major bleeding[41] from the covariates above (Table 1). We used Decision Maker® for Windows to automate the decision analysis calculations for each patient.

We automated the calculations using a SAS® Version 9.1 (SAS Institute Inc., Cary, NC, USA) script to develop batch input files for Decision Maker®. Parameter values for the covariates that predict stroke and bleeding risk identified in the 12-month period before the first atrial fibrillation diagnosis for each patient were input to Decision Maker. The output of the decision analysis for each patient was his or her predicted QALYs with and without anticoagulation.

Table 1. Risk Weights for Ischemic Stroke and Major Bleeding*

Clinical factor	Risk weights for	
	Ischemic stroke	Major bleed
History of diabetes mellitus	0.57	
History of hypertension	0.49	
History of congestive heart failure	0.36	
History of myocardial infarction	0.2	
Prior stroke/TIA		
Either past or present	0.99	0.84
Both past and present		1.69
Age		
<60	0	0
60–64	0.34†	0
65–69	0.34	1.03‡
70–79	0.68	1.03
80–89	1.02	1.03
History of gastrointestinal bleeding		1.12
Serious comorbid condition		1.04

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**This table should not be used for patients with "lone atrial fibrillation" younger than 65 years of age, as this is the referent group against which the weights for clinical risk factors were calculated. These patients have an annual stroke rate of 1%*
†*Increased risk per decade over age 60 years*
‡*Age ≥65 years*

Definition of Study Groups

The expected gain or loss conferred by anticoagulant therapy was determined by calculating the difference in expected utility (in QALYs) between the two strategies. If the calculated gain (ΔQALYs) was zero or greater, we considered this to be a positive recommendation for anticoagulation with warfarin. If the gain (ΔQALYs) was less than zero, anticoagulation was not recommended. These two groups were further stratified by whether they actually received treatment with warfarin or not, forming the four groups. Our overall goal was to determine whether there were fewer adverse events when the decision support tool and actual treatment were concordant. We had no control over who was prescribed warfarin.

Outcomes Assessment

Adverse events included acute stroke, acute gastrointestinal hemorrhage, and acute intracranial hemorrhage based on ICD-9-CM codes recorded on inpatient hospitalization claims. We only used first events from inpatient hospitalization codes to improve the reliability of diagnosis. We also inferred adverse events from the underlying cause of death revealed by ICD-9 codes for 1998 and ICD-10 codes for subsequent years in the Ohio death registry files.

Time at Risk

The date of a patient's initial atrial fibrillation diagnosis claim was used to define the start of the patient's period at-risk. Patients were censored at their date of disenrollment from Medicaid or on their date of death. For each outcome of interest, patients were included in the analysis only until the date of the first event, e.g., a patient with an acute stroke was removed from further analysis after the occurrence of the first stroke. As analysis was performed separately for each outcome, occurrence of gastrointestinal hemorrhage, for example, would not be counted as an adverse event or affect time at risk for acute stroke analysis.

Propensity Score for Receiving Warfarin

As this was an observational study in which clinicians and patients were free to make treatment decisions, it is likely that patients prescribed warfarin differed from those who did not receive warfarin. To correct for confounding by indication for warfarin treatment, we developed a propensity score to predict each patient's likelihood of receiving warfarin.[42] We used logistic regression to select the variables that were significant predictors at $p<0.10$ to be included in a multivariable model to predict the propensity score. Separate models were developed for the group of patients for whom the decision support tool recommended anticoagulation and for the group the tool recommended withholding anticoagulant therapy. We included this propensity score along with other covariates that might confound adverse outcomes in several Cox proportional hazard analyses to calculate adjusted adverse event rates in these groups.

Statistical Analysis

We used descriptive statistics, including the Student's t test and chi-square test, to characterize the study population. Event rates for each outcome (stroke, intracranial hemorrhage, and gastrointestinal bleeding) were calculated for each group and for the cohort as a whole.

We performed comparisons within the groups defined by the decision tool recommendations for or against warfarin. Subgroups for comparison were defined by actual treatment with warfarin or not. Cox proportional hazards models (SAS PROC PHREG) were used to determine the unadjusted and adjusted hazard ratios for the outcomes for each type of adverse outcome within each group. The proportional hazards assumptions were met, utilizing time-dependent covariates. The warfarin propensity score was forced into each adjusted model. Incorporating covariates for medications filled before the diagnosis and during the time at risk (including those at the $p<0.10$ significance) to the Cox proportional hazards models did not significantly alter the results.

RESULTS

Patient Characteristics

Two or more claims with ICD-9-CM code 427.31 were found among 25,200 patients. After the inclusion and exclusion criteria were applied, 6,123 patients remained in the cohort. These patients were followed for a mean of 581 days.

The mean (SD) age of the study population was 76.2 (13.4) years (Table 2). The majority of patients were women and were white. The population had numerous comorbidities, particularly hypertension, congestive heart failure, diabetes mellitus, and prior myocardial infarction. Many were prescribed analgesics and gastrointestinal protective medications. The decision support tool recommended warfarin for 3,008 patients (49%); however, only 298 (9.9%) of these were prescribed warfarin. Those who actually received warfarin tended to be younger,

Table 2. Cohort Characteristics for Four Groups, by Decision Support Tool Recommendation for Anticoagulation and Actual Treatment with Warfarin

	Anticoagulation per DST					No anticoagulation per DST				
	Warfarin treatment		No Warfarin treatment			Warfarin treatment		No Warfarin treatment		
	n	%	*n*	%	*p*	*n*	%	*n*	%	*p*
Observations	298	9.9	2,710	90.1		203	6.5	2,912	93.5	
Age, mean (SD)	68.6	(13.7)	74.6	(14.3)	<0.01	76.1	(10.1)	78.6	(12.1)	<0.01
White	241	80.9	2,100	77.5	0.18	175	86.2	2,354	80.8	0.06
Female	209	70.1	2,069	76.3	0.02	155	76.4	2,154	74	0.45
Hypertension	217	72.8	1,791	66.1	0.02	59	29.1	773	26.5	0.43
DM	132	44.3	1,161	42.8	0.63	22	10.8	335	11.5	0.77
CHF	167	56	1,505	55.5	0.87	39	19.2	630	21.6	0.42
Prior MI	55	18.5	478	17.6	0.73	22	10.8	336	11.5	0.76
Prior stroke	21	7	236	8.7	0.33	20	9.9	250	8.6	0.54
Recent stroke	5	1.7	42	1.5	0.87	15	7.4	168	5.8	0.34
Prior GI bleed	3	1	19	0.7	0.47*	16	7.9	402	13.8	0.02
Prior ICH	0	0	33	1.2	0.07*	0	0	26	0.9	0.41*
Prior other bleed	13	4.4	147	5.4	0.44	6	3	94	3.2	0.83
Comorbidity (any of the 3)	25	8.4	301	11.1	0.15	60	29.6	1,193	41	<0.01
Anemia	14	4.7	178	6.6	0.21	47	23.2	837	28.7	0.09
Renal disease	9	3	162	6	0.04	12	5.9	413	14.2	<0.01
Recent MI	6	2	68	2.5	0.6	9	4.4	182	6.3	0.3
Substance abuse	17	5.7	94	3.5	0.05	6	3	95	3.3	0.81
Psychiatric Dx	45	15.1	559	20.6	0.02	23	11.3	530	18.2	0.01
Social factors	50	16.8	655	24.2	<0.01	47	23.2	598	20.5	0.37
Non-compliance	97	32.6	1,151	42.5	<0.01	72	35.5	1,079	37.1	0.65
GI Med	152	51	1,528	56.4	0.08	93	45.8	1,537	52.8	0.05
Analgesics	228	76.5	1,984	73.2	0.22	157	77.3	1,897	65.1	<0.01
Steroids +	84	28.2	756	27.9	0.92	47	23.2	689	23.7	0.87
Other GI/anemia risk Rx	28	9.4	277	10.2	0.65	18	8.9	365	12.5	0.12
All cause mortality	91	30.5	1,323	48.8	<0.01	74	36.5	1,691	58.1	<0.01

p: Chi square
**Fisher's exact*

white, or on analgesics. Across the four study groups, covariates not statistically different included prior myocardial infarction, prior ICH, prior other bleed, and social factors.

Event rates for each outcome are presented for the cohort and by subgroup in Tables 3, 4 and 5. The stroke rate documented by Medicaid claims (3.37 per 100 patient years) is less than that reported in the literature (4.5% annually

Table 3. Adverse Outcomes of Acute Stoke, Major Gastrointestinal Hemorrhage, Intracranial Hemorrhage and Other Hemorrhage for Cohort

	N	%	Per 100py
Hospital Dx Ischemic Stroke*	316	5.2	3.37
Die from ischemic stroke†	242	4	2.58
All ischemic strokes‡	523	8.5	5.57
Hospital Dx GI bleed	516	8.4	5.6
Die from GI bleed	16	0.3	0.17
All GI bleed	530	8.7	5.76
Hospital Dx ICH	63	1	0.65
Die from ICH	10	0.2	0.1
All ICH	71	1.2	0.73
Hospital Dx other bleed	344	5.6	3.67
Die other bleed	0	0	0
All other bleed	344	5.6	3.67

**Hospital Dx are adverse events as documented by Ohio Medicaid inpatient claims, ICD-9 CM diagnoses*
†Ohio death registry adverse events, ICD-9 CM or ICD-10
‡Combined adverse event from both sources, a patient could either be counted as Hospital Dx or Die from, but not both for "All" outcome

Table 4. Adverse Outcomes of Acute Stoke, Major Gastrointestinal Hemorrhage, Intracranial Hemorrhage, and Other Hemorrhage for Group DST Recommended Anticoagulation

	Warfarin *N*=298			No warfarin *N*=2,710		
	n	%	Per 100py	*n*	%	Per 100py
Hospital Dx ischemic stroke*	17	5.7	3.44	141	5.2	3.44
Die from ischemic stroke†	7	2.35	1.42	91	3.36	2.22
All ischemic strokes‡	22	7.38	4.45	220	8.12	5.37
Hospital Dx GI bleed	23	7.72	4.56	206	7.6	5.09
Die from GI bleed	0	0	0	7	0.26	0.17
All GI bleed	23	7.72	4.56	213	7.86	5.27
Hospital Dx ICH	7	2.35	1.36	29	1.07	0.69
Die from ICH	0	0	0	5	0.18	0.12
All ICH	7	2.35	1.36	33	1.22	0.78
Hospital Dx other bleed	22	7.38	4.36	162	5.98	3.99
Die other bleed	0	0	0	0	0	0
All other bleed	22	7.38	4.36	162	5.98	3.99

**Hospital Dx are adverse events as documented by Ohio Medicaid inpatient claims, ICD-9 CM diagnoses*
†Ohio death registry adverse events, ICD-9 CM or ICD-10
‡Combined adverse event from both sources, a patient could either be counted as Hospital Dx or Die from, but not both for "All" outcome

Table 5. Adverse Outcomes of Acute Stoke, Major Gastrointestinal Hemorrhage, Intracranial Hemorrhage and Other Hemorrhage for group DST Recommended NOT to Anticoagulate

	Warfarin *N*=203			No warfarin *N*=2,912		
	N	%	Per 100py	*N*	%	Per 100py
Hospital Dx ischemic stroke*	11	5.42	2.79	147	5.05	3.34
Die from ischemic stroke†	9	4.43	2.28	135	4.64	3.07
All ischemic strokes‡	18	8.87	4.56	263	9.03	5.98
Hospital Dx GI bleed	28	13.79	7.53	259	8.89	6.04
Die from GI bleed	1	0.49	0.27	8	0.27	0.19
All GI bleed	29	14.29	7.79	265	9.1	6.18
Hospital Dx ICH	2	0.99	0.49	25	0.86	0.55
Die from ICH	0	0	0	5	0.17	0.11
All ICH	2	0.99	0.49	29	1	0.64
Hospital Dx other bleed	13	6.4	3.33	147	5.05	3.33
Die other bleed	0	0	0	0	0	0
All other bleed	13	6.4	3.33	147	5.05	3.33

**Hospital Dx are adverse events as documented by Ohio Medicaid inpatient claims, ICD-9 CM diagnoses*
†*Ohio death registry adverse events, ICD-9 CM or ICD-10*
‡*Combined adverse event from both sources, a patient could either be counted as Hospital Dx or Die from, but not both for "All" outcome*

untreated with warfarin from pooled analysis).[1] We found a large number of strokes among the Ohio mortality files were not documented in the Medicaid claims. Stroke event rates were not statistically different across the groups. Patients had a higher rate of gastrointestinal bleeding (5.76 per 100 patient years) compared with literature reported rates (1.3% per year in warfarin-treated patients).[1]

Hazard Ratios

In patients recommended for anticoagulation by the decision support tool, there was a trend towards a decreased hazard for stroke with actual warfarin treatment (Table 6). This difference did not become significant even after adjusting for the propensity of receiving warfarin and prescribed analgesics. Gastrointestinal bleeds, intracranial hemorrhage, and other bleeds were not significantly different between the two groups even after adjusting for the propensity of receiving warfarin. Adjusting for medications and other covariates not included in the decision support tool did not alter the findings.

In patients for whom withholding anticoagulation was recommended by the decision support tool (Table 7), there was a similar trend towards a decreased hazard of stroke in those who actually received warfarin. These patients had a statistically significant increased hazard of gastrointestinal bleeding. In the final adjusted Cox proportional hazards model using the covariate of propensity for warfarin prescribing, the relative hazard for gastrointestinal bleeding was 1.54 (p= 0.031). Hazard ratios for intracranial hemorrhage and other bleeds were not significant even after adjustment; however, there were few such outcomes in both groups. Adjusting for medications and other covariates not included in the decision support tool did not alter these findings.

Table 6. Hazard Ratios for Patients Recommended for Anticoagulation by the Decision Support Tool and Receiving Warfarin

	Anticoagulation recommended By DST			
	Referent group is those recommended for anticoagulation, but not actually receiving warfarin			
	Hazard ratio	Confidence interval		*P*
All strokes				
Unadjusted	0.835	0.538	1.294	0.419
Adjusted*	0.904	0.580	1.407	0.654
All GIB				
Unadjusted	0.867	0.564	1.333	0.516
Adjusted*	0.869	0.562	1.342	0.525
All ICH				
Unadjusted	1.743	0.771	3.940	0.182
Adjusted*	1.843	0.802	4.233	0.150
All other bleeds				
Unadjusted	1.093	0.700	1.706	0.697
Adjusted*	1.091	0.695	1.714	0.704

* *All adjusted models included the propensity score for receiving warfarin*

DISCUSSION

We have shown that there is a high risk of major bleeding in patients for whom our atrial fibrillation decision support tool recommends withholding anticoagulant therapy but who actually receive such treatment and that anti-coagulating these patients may actually result in more harm than benefit. Patients who received anticoagulation, but the decision tool indicated they should not, had a 54% increase in the hazard of gastrointestinal bleeding. We were unable to demonstrate an increase in intracranial hemorrhage and other bleeding events, likely caused by the small number of such events. Strokes were decreased with anticoagulation as expected, but not significantly. These results indicate that gastrointestinal hem-

Table 7. Hazard Ratios for Patients NOT Recommended for Anticoagulation by the Decision Support Tool But Actually Receiving Warfarin

	Anticoagulation NOT recommended by DST			
	Referent group is those not recommended for anticoagulation, and not receiving warfarin			
	Hazard ratio	Confidence interval		*p*
All strokes				
Unadjusted	0.782	0.485	1.260	0.312
Adjusted*	0.816	0.504	1.324	0.411
All GIB				
Unadjusted	1.293	0.881	1.897	0.189
Adjusted*	1.539	1.040	2.271	0.031
All ICH				
Unadjusted	0.779	0.186	3.267	0.733
Adjusted*	0.823	0.195	3.545	0.804
All other bleeds				
Unadjusted	1.013	0.574	1.787	0.964
Adjusted*	1.008	0.567	1.793	0.978

**All adjusted models included the propensity score for receiving warfarin*

orrhage occurred at a greater rate compared to prevention of major stroke. Thus, the risk of anticoagulation likely outweighs its benefit in this group of patients for whom the decision support tool recommended withholding anticoagulant therapy.

In the group of patients for whom the decision support tool recommended anticoagulation therapy, there was a non-statistically significant trend towards a decreased hazard of stroke in those receiving anticoagulant therapy with no increased hazard of gastrointestinal bleeding. The lack of a statistically significant difference in stroke hazard may be secondary to the low overall use of warfarin in this cohort.[12–20] As expected, intracranial hemorrhage and other bleeding were increased with warfarin use. While intracranial hemorrhage is devastating, the absolute risk is small. Furthermore, data are lacking to accurately predict future intracranial hemorrhage risk with resumed anticoagulation.[43–45]

Our study has several limitations. First, we did not have laboratory information documenting the intensity of anticoagulation therapy (i.e., INR values). Consequently, we were not able to adjust our analyses for the intensity of anticoagulation. Second, we were unable to account for the effect of aspirin use on outcomes. Aspirin reduces the risk of stroke, but it is not as effective as warfarin.[46–48] Third, we could not reliably identify new subsequent events following the first adverse event (e.g. second stroke). Additionally, major bleeding occurred more frequently than expected. These reflect some of the limitations of using administrative data.[49–52] Chart review would enhance the accuracy of diagnoses and warfarin and aspirin use. Lastly, this study can address neither individual patient preferences for receiving warfarin or for different health states nor physician barriers to warfarin use.

This study's approach might be helpful for preclinical testing other decision support tools, especially with an appropriate dataset. The sole use of administrative data for this preclinical testing may not be sufficient because of issues of completeness and accuracy of the information contained in claims data. This concern is further highlighted by our finding a significant additional number of strokes through the examination of death registry information.

These preliminary results suggest that use of the atrial fibrillation decision support tool might result in more appropriate prescribing of warfarin particularly in patients for whom the balance of risk and benefit favors not treating. The low use of warfarin in this Ohio Medicaid cohort makes it difficult to tell whether the trend towards a decreased risk of stroke in those treated with warfarin concordant with the decision tool's recommendation is significant. However, a clinical trial of the decision support tool would further clarify the impact and could incorporate physician decision making and patient preferences into the actual treatment decision. We envision the tool better informing such a shared decision making approach, not a substitute for patient-provider discussion.

In conclusion, our study of Ohio Medicaid patients with non-valvular atrial fibrillation demonstrated that a decision support tool for anticoagulation recommendations could identify patients at significant risk for gastrointestinal hemorrhage in whom the decision to anti-coagulate should be weighed more cautiously. The decision support tool suggested that 49% of patients should be considered for anticoagulation, whereas only 9.9% actually received such therapy in this group. Administrative claims data and death files may be insufficient to adequately test decision support tools for all outcomes before clinical trials or use. Further testing of the decision support tool in a clinical setting is desirable to determine if its use can significantly reduce acute strokes while only modestly increasing hemorrhagic events.

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