Examining Warfarin Dosing Decisions to Improve Anticoagulation Management

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Abstract

Background: Adherence to relatively simple warfarin dosing algorithms has been found to be effective for improving anticoagulation control, and in turn for reducing adverse events. Achieving consistent use of such algorithms by clinicians managing the care is a known challenge. **Objective:** To examine warfarin management patterns at anticoagulation clinics in light of algorithm-recommended management and to develop a methodology for quality assurance around this issue. **Methods:** We reviewed 2711 postappointment clinician notes between October 1, 2011, and March 31, 2012, for 481 patients across 5 Veterans Health Administration (VA) sites. Key data gathered were of dosing decisions made following the latest available international normalized ratio (INR). **Results:** Dosing decisions discordant with algorithm recommendations were made at 45% of all the appointments studied; most (78%) followed an out-of-range INR value, as opposed to an in-range value. We found “signatures of care” at each site, characterized by consistent patterns of concordant and discordant management. For example, some sites were more discordant in terms of one-time dose changes (eg, take an extra dose for 1 day), while others were more discordant regarding follow-up intervals, and still others regarding the extent of weekly dose changes (usually larger than recommended). It was also not uncommon to change the dose following an in-range value (not recommended). **Conclusions:** We identified 5 distinct patterns of management across 5 sites; none were particularly adherent to clinical guidelines. Our method is a suitable basis for audit and feedback to help sites improve patient outcomes by practicing in a more guideline-concordant manner.

Keywords

anticoagulants, medication therapy management, quality assurance, standards of practice, warfarin

Better anticoagulation control reduces the risk of stroke and other thromboembolic events,^{1–4} which is of concern to millions of patients each year.⁵ Oral vitamin K antagonists such as warfarin are the most widely used anticoagulants⁶; their effectiveness in maintaining a patient’s international normalized ratio (INR) within a clinically recommended target range depends heavily on the process of care through which their administration is managed.⁷ In particular, adherence to relatively simple warfarin dosing algorithms has been found to be effective for improving anticoagulation control.^{7,8}

Achieving consistent use of such algorithms by clinicians managing the care, however, is a known challenge.⁹ A warfarin dosing algorithm, or any algorithm for care delivery, serves at most as a guide that a clinician can refer to before making the final decision on what action to take for managing the patient’s condition.⁶ Despite recent studies strongly suggesting that algorithm-concordant care could lead to improved patient outcomes,^{7,8} there is little evidence as of yet that the use of warfarin dosing algorithms is actually on the rise.⁹

This emerging evidence has led to widespread efforts to implement algorithm usage at clinics, as a key component of improving anticoagulation care.⁹ But the extent to which

an algorithm is adopted for use by clinicians cannot be accurately assessed without a method to track dosing decisions that they are making in light of algorithm-recommended warfarin management. We aimed to fill this gap through our study, which explores the use of data from post-appointment clinician notes to understand warfarin management patterns.

Examining data from 5 related anticoagulation clinics, our goal was to determine whether our approach can serve as a tracking method that effectively provides answers to the following questions: (a) How do the clinics’ dose management decisions compare against algorithm recommendations? (b) Under what circumstances do dosing decisions generally align with or deviate from algorithm-concordant practice? (c) Do management decision patterns differ from clinic to clinic? A method that can answer these questions

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would benefit algorithm implementation efforts by demonstrating the extent to which the algorithm has been adopted (ie, to what extent the care being delivered is consistent with clinical guidelines); such a method can in turn contribute both to assuring the quality of care and to planning further strategies to improve anticoagulation management.

Methods

We studied warfarin management patterns from October 1, 2011, to March 31, 2012, for 5 sites within Veterans Health Administration's (VA) Boston Healthcare System (BHS), referred to here as Sites A through E. We reviewed postappointment clinician notes in VA's electronic health record system over the 6-month period, for 100 randomly selected patients from each of Sites A, B, C, and E, and for all 81 patients on record for Site D. Generally accepted dose management practices for initiating warfarin therapy (or reinitiating warfarin therapy after discontinuation) differ from that of continuing warfarin therapy; we focused on examining practices for the latter. We therefore excluded clinical encounters that took place within the first 6 weeks of a patient being on warfarin therapy, as well as within 2 weeks of a patient being back on warfarin therapy after a discontinuation (eg, due to preparation for a procedure, hospitalization, etc).

Warfarin management is monitored using a patient's INR, which is measured at intervals through a blood test; an in-range INR value implies successful anticoagulation control, while an out-of-range INR value signals a possible need for change in the warfarin dose administered to the patient. Sites A, B, and C obtain patients' INRs using venipuncture only, while Sites D and E use point-of-care testing for most tests. Given the patient's latest INR value and goal INR range, recommended management actions are outlined in Table 1, which is based on the algorithm published by Kim et al⁸ and similar to others that are in widespread use.

From each of the 2711 notes total, we gathered data on dosing decisions made following the latest available INR. Specifically, we noted the date of the appointment, goal INR range, latest available INR, weekly warfarin dose leading up to the appointment, and the clinician's dosing decision regarding the following categories:

- Change in weekly dose following the appointment
- Number of days until the next appointment (follow-up interval)
- One-time dose change (eg, take an extra dose for 1 day)

The data were manually recorded using Excel spreadsheet software and analyzed using its associated Visual Basic programming language (Microsoft Corporation, Redmond, WA). This evaluation tool, along with directions for its use, is provided in the appendix.

We compared the dosing decision made at each appointment against management actions recommended in Table 1. We deemed a decision concordant if, given the latest available INR, it took actions as suggested by the algorithm. Otherwise, we deemed the decision discordant, and noted in what ways it was so (ie, whether it changed the weekly dose, requested a follow-up appointment date, or ordered a one-time dose change, not as suggested by the algorithm). Plausible changes in weekly dose are limited to multiples of half of the warfarin tablet that a patient is taking. For example, for a patient taking 2 mg tablets, dose changes smaller than 1 mg/day cannot easily be accomplished. Therefore, we considered a dose change to be concordant if it changed as closely as possible to the algorithm-recommended amount using the available tablets. For example, if a dose increase of 10% to 15% were recommended for a patient using 5 mg tablets for an initial weekly dose of 32.5 mg, we considered a 5 mg increase to be concordant, even though it would not be exactly the recommended dose change (3.25–4.875 mg). Also, we considered a follow-up interval to be discordant only if it was longer than the maximum algorithm-recommended number of days. Then, for each patient, we calculated the percentage of his or her appointments at which algorithm-concordant decisions were made over the 6-month period.

This study belonged to a series of improvement projects classified to be not constituting research as described in VHA Handbook 1058.05 (and in turn exempt from human subjects review) by the Improvement Resources Office in Veterans Integrated Service Network 1 (New England Healthcare System).

Results

We included 481 patients from 5 sites, 100 each at 4 sites and 81 at the other (because no further patients were available at that site). Dosing decisions discordant with algorithm recommendations were made at 45% of all the appointments studied (1209 out of 2711). These decisions took place even when the INR was in-range; 22% followed an in-range INR value (271 out of 1209), while the remainder followed an out-of-range value. Only 19% of the patients studied (90 out of 481) had algorithm-concordant decisions made at more than 80% of their appointments over the 6-month period.

Figure 1 depicts the number of appointments at which the dosing decision was discordant with algorithm recommendations, in terms of weekly dose change, follow-up interval, and/or one-time dose change. Fifty-one percent of the discordant dosing decisions (613 out of 1209) were associated with the weekly dose change not being as suggested by the algorithm; 23% (282 out of 1209) were discordant only in terms of this weekly dose change, and not in terms of follow-up interval or one-time dose change. Similarly, 51%

Table 1. Recommended actions for ongoing warfarin management given a patient's goal INR range and latest INR^a.

Goal of INR 2.0-3.0		Goal of INR 2.5-3.5	
Latest INR	Recommended Action	Latest INR	Recommended Action
≤1.5	Increase weekly dose by 10% to 15%; repeat INR within 7 days.	≤1.5	Increase weekly dose by 10% to 15%; repeat INR within 7 days.
1.51-1.79	If falling or low on 2 or more occasions, increase weekly dose by 5% to 10%; repeat INR in 7-14 days.	1.51-1.99	If falling or low on 2 or more occasions, increase weekly dose by 10% to 15%; repeat INR in 7-14 days.
1.80-1.99	Consider not changing the dose unless a consistent pattern has been observed; repeat INR in 7-14 days.	2.00-2.29	If falling or low on 2 or more occasions, increase weekly dose by 5% to 10%; repeat INR in 7-14 days.
2.00-3.00	No change in dose. Follow-up within 28 days. If INR has been in-range 3× consecutively, follow-up within 42 days.	2.30-2.49	Consider not changing the dose unless a consistent pattern has been observed; repeat INR in 7-14 days.
3.01-3.20	Consider not changing the dose unless a consistent pattern has been observed; repeat INR in 7-14 days.	2.50-3.50	No change in dose. Follow-up within 28 days. If INR has been in-range 3× consecutively, follow-up within 42 days.
3.21-3.69	Do not hold warfarin. If rising or high on 2 or more occasions, decrease weekly dose by 5% to 10%; repeat INR in 7-14 days.	3.51-3.70	Consider not changing the dose unless a consistent pattern has been observed; repeat INR in 7-14 days.
3.70-4.99	Hold for 1 day and decrease weekly dose by 5% to 10%; repeat INR determination within 7 days.	3.71-4.19	Do not hold warfarin. If rising or high on 2 or more occasions, decrease weekly dose by 5% to 10%; repeat INR in 7-14 days.
5.00-9.99	Hold warfarin. Restart at lower dose (decrease weekly dose by 10% to 15%) when INR is therapeutic. Check INR at least weekly until stable.	4.20-4.99	Hold for 1 day and decrease weekly dose by 5% to 10%; repeat INR determination within 7 days.
≥10.0	Hold warfarin and give oral vitamin K, 2.5 mg. Check INR at least weekly until stable.	5.00-9.99	Hold warfarin. Restart at lower dose (decrease weekly dose by 10% to 15%) when INR is therapeutic. Check INR at least weekly until stable.
		≥10.0	Hold warfarin and give oral vitamin K, 2.5 mg. Check INR at least weekly until stable.

Abbreviation: INR, international normalized ratio.

^aIf serious bleeding, hold warfarin regardless of INR and immediately refer patient to emergency department. **Figure 1.** Number of appointments at which dosing decision was discordant with algorithm recommendations, in terms of weekly dose change, follow-up interval, and/or one-time dose change, for (A) all discordant decisions (1209 total) and (B) discordant decisions following INR values in goal range (271 total).

Note. The numbers on the outside of each circle do not add up to the totals, since some decisions were discordant in terms of more than one category (eg, 4 out of 271 discordant decisions made following in-range INRs were discordant in terms of both weekly dose change and follow-up interval).

Figure 2. Pattern of discordance with algorithm recommendations varies by site.

(622 out of 1209) were associated with the follow-up interval not being as suggested by the algorithm; 26% (316 out of 1209) were discordant only in terms of this follow-up interval, and not in terms of weekly or one-time dose changes. For discordant decisions made following in-range INRs, 55% (148 out of 271) were associated with the follow-up interval not being as suggested by the algorithm, while 43% (117 out of 271) were associated with the weekly dose change not being as suggested; one-time changes were significantly fewer at 5% (13 out of 271). Note that the percentages do not add up to 100%, since some decisions were discordant in terms of more than one category (eg, 4 out of 271 discordant decisions made following in-range INRs were discordant in terms of both weekly dose change and follow-up interval, as shown in Figure 1).

The pattern of discordance with algorithm recommendations varied by site, as shown in Figure 2. Site A was approximately 2 times more discordant in weekly dose change and follow-up interval than in one-time dose change. Site B was relatively evenly discordant in all 3 categories, while the prevalence of one-time dose change was more noticeable for Site C. Site D was approximately 2 times more discordant in weekly dose change than in the other 2 categories, while Site E was approximately 2 times more discordant in follow-up interval than in the other 2 categories. Even for discordant decisions made following in-range INRs, weekly dose change was a prominent pattern of discordant behavior for Site D, and follow-up interval was prominent for Site E.

Discussion

This study demonstrates that data on clinicians' dosing decisions can be used to understand site-specific patterns of warfarin management for anticoagulation care. We found (a) a general low adherence to clinical guidelines, (b) dosing changes discordant with algorithm recommendations even following in-range INRs, and (c) 5 distinct patterns of

management across 5 sites. This analysis provides the sites with a clear picture of where they each currently stand in terms of delivering guideline-concordant care.

This information is indispensable for sites that are aiming to improve clinic practices toward algorithm-recommended management. For instance, the most common approach to any improvement is to iteratively attempt changes, where each change would be planned, carried out, then evaluated, before being kept, altered, or discarded.^{10,11} The evaluation step of this iteration requires an objective snapshot of current state practices, in order to plan next steps based on whether a change has been effective; our approach can provide this snapshot to clinics for improving adherence to clinical guidelines for warfarin dosing. The need for change in practice toward evidence-based algorithm-recommended management can be most persuasive when providers' own practices can be accurately demonstrated to them. Our study offers an approach to do exactly this, collecting and analyzing data from the very postappointment notes that the providers have completed.

The limited availability of automated data on warfarin dosing has been identified as a challenge for implementing a dosing algorithm, as adherence to the algorithm cannot be easily tracked to measure its uptake.⁹ While we performed a laborious manual collection of data, it would be feasible to design a system to collect such data routinely in a structured format at each visit. Our method solely relies on dosing data that is feasible to collect from clinicians into an electronic health record system using a template; for every appointment, the data fields to be filled out would only be the (a) latest INR, (b) weekly dose leading up to the appointment, (c) updated weekly dose, (d) one-time dose change for a set number of days, and (e) next appointment date, values for which clinicians are already typing into their mostly free-text-based electronic postappointment notes. (We assume that data fields for the appointment date and goal INR range can be automatically populated and carried over from previous patient records, respectively.) Moreover, the field entries on the template can

be designed as selections from dropdown lists to minimize typographic error, and the algorithm recommendations can be made available on the same screen for clinicians to consult. Such a system would serve the dual purposes of facilitating documentation while allowing the collection of data for quality improvement and research.

There are limitations to our work. First, we only examined management at these 5 sites over a single time period. We do plan to collect similar data from these 5 sites as a follow-up study, to see if their practice has changed in the interim. The region in which these sites are located is conducting a project to promote the use of algorithmic management of warfarin, so we might expect that these sites have improved. The present study has an important role in this ongoing project, by documenting the extent to which baseline practices were discordant with what would be recommended by the algorithm. Having this information in-hand has been an important tool for us so far to help convince clinicians that they do need to change. Second, it should be noted that we studied sites that operate under one integrated healthcare system. Nevertheless, we have every reason to expect that the more usual setting of community-based anticoagulation management would also

show great variation and suboptimal concordance with a warfarin management algorithm.⁷ Third, rates of comorbid illness, as well as of mental illness and substance abuse disorders, are higher for VA patients than for the general population. However, there is no reason to think that these factors would detract from the value of the algorithm we studied in terms of improving anticoagulation control and, therefore, outcomes.

Despite these limitations, our work offers a novel approach of using warfarin dosing data to shed light on current management practices at anticoagulation clinics. Improving adherence to clinical practice guidelines is a known challenge¹²; management patterns identified through our approach can serve as a basis for audit and feedback to help sites improve patient outcomes by practicing in a more guideline-concordant manner. And as our method requires no more data than is already commonly provided by clinicians in postappointment notes, our future work looks to further specify a design for template-based data collection, which can make the use of data on dosing decisions even more feasible for any clinic targeting an improvement in anticoagulation management.

Appendix

The Evaluation Tool Used for the Chart Review, Together With Directions for Its Use

	Column	Description
Input From Chart	A	Enter the site ID.
	B	Enter the patient ID.
	C	Number the appointments reviewed for each patient, from least recent to most recent.
	D	Enter the date of appointment.
	E	Enter the goal INR range, 2.0-3.0 or 2.5-3.5.
	F	Enter the lower bound for the goal INR range.
	G	Enter the upper bound for the goal INR range.
	H	Enter the INR value.
	I	The tool automatically fills in a 1 if the INR is in range, and a 0 if not.
	J	Enter the smallest possible increment of change in weekly dose (eg, 1 if patient is taking 2 mg pills, 2.5 if patient is taking 5 mg pills).
	K	Enter 1 if a notable event affected the management decision and make note of the event in Column W; else, enter 0.
	L	Enter 1 if there was intentional cessation of warfarin and make note of the reason in Column W; else, enter 0.
	M	Enter the weekly dose (in mg) that the patient was taking leading up to the appointment.
	N	Enter the updated weekly dose (in mg) that is assigned to the patient at the appointment.
	O	The tool automatically calculates the decided change in weekly dose.
	P	Enter the decided date of return to the clinic for the next appointment.
	Q	The tool automatically calculates the follow-up interval.
	R	Enter the decided number of days to hold warfarin for.
	S	Enter 1 if oral vitamin K was administered; else, enter 0.
	T	Enter 1 if the decision was to hold warfarin until the next appointment; else, enter 0.
	U	Enter 1 if a temporary (not weekly) change in warfarin dose was decided and enter the amount in Column V; else, enter 0.
	V	See description for Column U.
	W	Add any additional details of interest from the chart.

(continued)

Appendix (continued)

	Column	Description
Track Discordance in Weekly Dose	X	Based on a built-in formula for each column, the tool fills in a 1 if, given the INR value and goal range, the management decision involved a dose change that is not recommended by the algorithm, and a 0 if not.
	Y	
	Z	
	AA	
	AB	
	AC	
	AD	
	AE	
	AF	
	AG	
Follow-up Interval	AH	Based on a built-in formula for each column, the tool fills in a 1 if, given the INR value and goal range, the management decision involved a follow-up interval that is not recommended by the algorithm, and a 0 if not.
	AI	
	AJ	
	AK	
	AL	
	AM	
	AN	
	AO	
	AP	
	AQ	
	AR	
	AS	
	AT	
One-Time Change	AU	Based on a built-in formula for each column, the tool fills in a 1 if, given the INR value and goal range, the management decision involved a one-time change that is not recommended by the algorithm, and a 0 if not.
	AV	
	AW	
	AX	
	AY	
	AZ	
	BA	
	BB	
Eval	BC	Based on Columns X through BB, the tool fills in a 1 if the management decision at the appointment was concordant with algorithm recommendations, and a 0 if not.

Note. Concordance evaluated for each appointment in Column BC is ready to be subsequently analyzed in conjunction with information recorded in earlier columns (eg, Columns A, I, and X-BB, for understanding concordance along site-specific, in-range vs out-of-range, and discordance pattern dimensions, respectively).

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Authors' Note

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