Quality Improvement Initiative for Pharmacist-Assisted Warfarin Dosing: Implementation and Evaluation of a New Protocol

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ABSTRACT

Background and Objective: A Pharmacist-Assisted Warfarin Dosing (PAWD) program was implemented for patients in the cardiac program of the authors' hospital in 1996. Within the PAWD program, certified pharmacists, under the direction of physicians, are responsible for warfarin dosing according to an approved protocol. The aim of the program was to have the international normalized ratio (INR) of at least 70% of patients within the therapeutic range at day 4 or 5 after initiation of therapy. However, a preliminary assessment showed that pharmacists were able to use the approved protocol for only 50% of the doses ordered, and only 61% of patients reached the therapeutic range by day 4. A quality improvement initiative was undertaken, and the warfarin protocol was modified. The current study reports the results of a retrospective comparison of outcomes before and after the quality improvement initiative.

Methods: The authors compared outcomes for 59 patients enrolled in the PAWD program under the original protocol and 28 patients under the updated protocol.

Results: Pharmacists were able to follow the updated protocol in a greater proportion of cases than had been the case with the original protocol. In addition, the mean INR was more often within the therapeutic range when the updated protocol was used, reaching statistical significance on days 5 and 6. Bleeding developed infrequently with either protocol, and vitamin K was used sparingly. Thrombosis did not occur in any patients.

Conclusions: Through a continuous quality improvement process, the PAWD program was enhanced and the number of days on which INR was within the therapeutic range increased. These improvements should reduce the frequency of negative patient outcomes (e.g., adverse or thromboembolic events).

Key words: anticoagulation, pharmacist, warfarin

RÉSUMÉ

Généralités et objectif : Un programme de dosage de la warfarine assisté du pharmacien (PAWD) a été mis en place en 1996 pour les patients du programme cardiaque de l'hôpital auquel sont rattachés les auteurs de l'étude. Dans le cadre du programme PAWD, des pharmaciens agréés, sous la direction des médecins, étaient responsables du dosage de la warfarine, conformément à un protocole établi. L'objectif du programme était d'obtenir, au jour 4 ou au jour 5 après le début du traitement, un rapport international normalisé (RIN) dans la marge thérapeutique chez au moins 70 % des patients. Cependant, une évaluation préliminaire a montré que les pharmaciens se conformaient au protocole établi pour seulement 50 % des doses prescrites, et que seulement 61 % des patients étaient dans la marge thérapeutique au jour 4. Une initiative d'amélioration de la qualité a été entreprise et le protocole de dosage de la warfarine a été modifié. La présente étude fait état des trouvailles d'une comparaison rétrospective de l'évolution de l'état des patients avant et après l'initiative d'amélioration de la qualité.

Méthodes : Les auteurs ont comparé l'évolution de l'état de 59 patients qui ont participé au programme PAWD selon le protocole initial et celle de 28 patients ayant participé au programme selon le protocole révisé.

Résultats : Les pharmaciens ont pu se conformer au protocole révisé dans une plus grande proportion des cas qu'ils ne l'ont fait avec le protocole initial. En outre, le RIN moyen était plus souvent dans la marge thérapeutique avec le protocole révisé, ce qui était statistiquement significatif aux jours 5 et 6. Des hémorragies sont survenues rarement avec l'un ou l'autre protocole, et on a eu recours de façon restreinte à la vitamine K. Aucun patient n'a souffert de thrombose.

Conclusions : Grâce à une initiative d'amélioration continue de la qualité, le programme PAWD a pu être perfectionné et le nombre de jours où le RIN était dans la marge thérapeutique a augmenté. Ces améliorations devraient réduire la fréquence des résultats thérapeutiques négatifs (comme des réactions indésirables ou des accidents thromboemboliques).

Mots clés : anticoagulants, pharmacien, warfarine

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INTRODUCTION

Quality improvement is defined as the commitment and approach used to continuously improve every process in every part of an organization, with the intent of meeting and exceeding customer expectations and outcomes.[1] It has become a fundamental concept in health care institutions. Many hospitals have implemented organization-wide quality improvement programs. Although quality improvement initiatives can target large hospital programs, the same techniques also have practical application to specific aspects of patient care.

One systematic method of identifying quality problems is through the Plan, Do, Check, Act (PDCA) cycle.[1] In the first step, "Plan," customer groups are identified and their unique needs and the characteristics of quality they value most are defined. Then a program is developed to meet those needs. In the second step, "Do," the program or service is delivered. Then, a "Check" is performed by continuous measurement and analysis of key aspects of quality; during this stage, the data are compared with customer needs and expectations. Finally, during the last step, "Act," the system and the product or service are refined and improved.

At The Toronto Hospital, it was determined that the warfarin dosing and prescribing process could be improved. It was recognized that pharmacists have the expertise to assist the health care team in warfarin dosing. Thus, the PDCA cycle was initiated and a "Plan" was created for a program that would allow pharmacists to be more actively involved in warfarin prescribing. In 1994, the Pharmacist Assisted Warfarin Dosing (PAWD) program was developed. This program allowed physicians to direct pharmacists to dose for warfarin according to an approved protocol. The results of the development, implementation, and evaluation of the PAWD pilot program have been published previously.[2] On the basis of the positive results of the pilot project, the PAWD program received hospital approval, and it was implemented in the cardiac program in 1996.

To ensure the quality of the program, a "Check" was performed through a retrospective program review. The aim of the program was to have at least 70% of patients in the therapeutic range of international normalized ratio (INR) at day 4 or 5. Warfarin prescribing was based on institutional guidelines. The pharmacists were able to use the approved guidelines for only approximately 50% of the doses ordered. Program evaluation revealed that only 61% of patients reached the therapeutic range by day 4. On the basis of these results, it was recognized that the PAWD program needed improvement. The warfarin protocol was then modified.

The purpose of this report is to describe the PAWD quality improvement initiative, the impact of the new warfarin protocol on achieving target INR, and the ease of use of the new warfarin protocol.

PAWD QUALITY IMPROVEMENT INITIATIVE

Details of the PAWD program have been described previously.[2] In brief, certified pharmacists, under the direction of a physician, use an approved protocol to determine warfarin dosing for cardiology patients. The program operates 7 days a week, and is carried out by practising pharmacists on the cardiology ward. A physician writes an order requesting PAWD and provides a specified target therapeutic INR. Once the warfarin dose is determined (from the protocol), the pharmacist writes the order according to institutional policy. The order is written as a verbal order from the initiating physician, a format that requires cosignature within 24 h. If, in the pharmacist's clinical judgement, the patient requires a dose outside of the approved protocol, the responsible physician is contacted. If reversal of anticoagulation is needed, the pharmacist makes recommendations to the house officer or a designate.

The original cardiology protocol incorporated institutional anticoagulation guidelines prepared by the hematologist-in-charge and the Department of Pharmacy Services (Figure 1).[3-6] Review of the program revealed that the original warfarin protocol was being followed only 50% of the time. As observed during initial program development and implementation,[2] the protocol was most useful in initiating warfarin therapy for days 1 to 5. However, subsequent dose adjustments were more effectively determined from patient trends. It was recognized that the guidelines required improvement in the area of maintenance dose adjustment. The protocol was then modified (Figure 2) to allow pharmacists greater flexibility in dosing, both before and particularly after day 5.[7,8] Modifications were made by the pharmacy clinical coordinator and the hematologist-in-charge. These modifications were based on the mean patient responses that had been observed when the old protocol was in place. The PAWD program was continued with the new protocol once it had been approved by the Pharmacy and Therapeutics Committee and the Medical Advisory Committee.

Target INR 2.5

Thrombosis, thromboemboli, and excess clotting associated with deep vein thrombosis; venous thromboembolism; bioprosthetic heart valve

First Day		Second Day		Third Day		Fourth Day and Onward	
INR	Dose (mg)	INR	Dose (mg)	INR	Dose (mg)	INR	Dose (mg)
<1.3	10	< 1.3	10	<1.6	10	<1.8	10
1.3–1.5	5	1.3–1.5	5	1.6–1.8	7.5	1.8–2.1	7.5
>1.5	Nil	>1.5	Nil	1.81–2.1	5	2.11–2.4	5
				2.11–2.4	2.5	2.41–2.5	2.5
				2.41–2.7	1.25	2.51–2.7	1.25
				> 2.7	Nil	>2.7	Nil

Target INR 3.5

Thrombosis or thromboemboli and excess clotting associated with mechanical heart valves and intravascular devices; arterial thromboembolism

First Day		Second Day		Third Day		Fourth Day and Onward	
INR	Dose (mg)	INR	Dose (mg)	INR	Dose (mg)	INR	Dose (mg)
<1.3	10	<1.3	10	<1.7	10	<2	10
1.3–1.5	5	1.3–1.5	5	1.7–2.2	7.5	2.0–2.5	7.5
>1.5	Nil	>1.5	Nil	2.21–2.7	5	2.51–3.0	5
				2.71–3.2	2.5	3.01–3.4	2.5
				3.21–3.6	1.25	3.41–3.7	1.25
				>3.6	Nil	>3.7	Nil

INR increases too early after starting warfarin
OR
INR increases too much after starting warfarin

If INR increases by 0.5 after *any dose:*
Give only *half* dose recommended for INR.

If INR increases by >1 after *any single dose:*

1. Check for liver disease, drug interference, poor nutrition, vitamin K intake, diet, diarrhea, etc.
2. Give only one-quarter (25%) of the dose.

INR fails to increase
OR
INR increases too little according to the expected dose–response relation

If INR not >1.3 after 4 consecutive doses of 10 mg:

1. Check for ingestion of vitamin K (e.g., nutrition supplements, seaweed or ethnic food, kale, proprietary vitamins)
2. Crush tablet, dissolve in water, and watch patient swallow medication with a juice chaser.

If still no increase in INR after 24–48 h:
Use twice dose recommended, but check INR carefully.

If INR stops increasing after initial satisfactory response:
Check diet, drug, and compliance again.

Figure 1: Original protocol for warfarin dosing.

ASSESSMENT OF NEW PROTOCOL

A retrospective analysis was performed by a single reviewer, who compared patients treated according to the old protocol and the new protocol. Clinical notes and laboratory values were recorded on pharmacy patient profiles. Data from the pharmacy patient profiles were confirmed through the hospital laboratory computer system and the inpatient pharmacy computer system. All retrospective data were entered into a standardized database. The data consisted of patient sex, age, history of bleeding, anticoagulation on admission, interacting medications, and hepatic dysfunction. All patients receiving warfarin, including those who received the drug before program enrollment and those receiving medications interacting with warfarin, were included in the analysis. The indications for warfarin were summarized, as were the percentages of patients who received the interacting medications.

Target INR 2.5 (2.0–3.0)

Thrombosis, thromboemboli, and excess clotting associated with deep vein thrombosis; venous thromboembolism; bioprosthetic heart valve

Day 1		Day 2		Day 3		Day 4 to 10	
INR	Dose (mg)	INR	Dose (mg)	INR	Dose (mg)	INR	Dose (mg)
<1.3	7.5–10	<1.3	7.5–10	<1.6	7.5–10	<1.8	7.5–10
1.3–1.5	5–7.5	1.3–1.5	5–7.5	1.6–1.8	5–7.5	1.8–2.1	5–7.5
1.51–1.7	2.5–5	1.51–1.7	2.5–5	1.81–2.1	2.5–5	2.11–2.4	2.5–5
>1.7	0–2.5	>1.7	0–2.5	2.11–2.4	2–4	2.41–2.5	2–4
				2.41–2.7	0–2	2.51–2.7	0–3
				>2.7	0–1	>2.7	0–2

Note: For patients on amiodarone, ciprofloxacin, or cotrimoxazole, start with 50% of the suggested dose. Take into consideration drug and disease factors (e.g., prior maintenance dose, medical conditions such as congestive heart failure, and body weight and nutrition).

After Day 10

Average the doses for the patient from day 4 to day 10 to determine a total weekly warfarin dose. Adjust the weekly warfarin dose according to INR on day 10 as listed below. Adjust for subsequent weeks in a similar manner.

INR on day 10	Change in Weekly Warfarin Dosage
<1.5	Increase weekly dose by 30% to 50%.
1.51–1.99	Increase weekly dose by 10% to 30%.
2–3	Keep same weekly dose.
3.1–4.0	Decrease weekly dose by 10% to 30%.
4.01–4.5	Decrease weekly dose by 30% to 50%. Consider holding 1 or 2 doses depending on bleeding risk.
>4.51	Decrease weekly dose by 40% to 60%. Hold 1 or 2 doses. Assess bleeding status and risk.

Target INR 3.0 (2.5–3.5)

Thrombosis or thromboemboli and excess clotting associated with mechanical heart valves and intravascular devices; arterial thromboembolism

Day 1		Day 2		Day 3		Day 4 to 10	
INR	Dose (mg)	INR	Dose (mg)	INR	Dose (mg)	INR	Dose (mg)
<1.3	7.5–10	<1.6	7.5–10	<1.8	7.5–10	<2	7.5–10
1.3–1.5	5–7.5	1.6–1.8	5–7.5	1.81–2.2	5–7.5	2.0–2.5	5–7.5
1.51–1.7	2.5–5	1.81–2.2	2.5–5	2.21–2.8	2.5–5	2.51–3.0	2.5–5
>1.7	0–2.5	>2.2	0–2.5	2.81–3.2	2–4	3.01–3.5	2–4
				3.21–3.6	0–2	3.51–3.7	0–3
				>3.6	0–1	>3.7	0–2

Note: For patients on amiodarone, ciprofloxacin, or cotrimoxazole, start with 50% of the suggested dose. Take into consideration drug and disease factors (e.g., prior maintenance dose, medical conditions such as congestive heart failure, and body weight and nutrition).

After Day 10

Average the doses for the patient from day 4 to day 10 to determine a total weekly warfarin dose. Adjust the weekly warfarin dose according to INR on day 10 as listed below. Adjust for subsequent weeks in a similar manner.

INR on Day 10	Change in Weekly Warfarin Dosage
<1.5	Increase weekly dose by 50% to 60%.
1.51–1.9	Increase weekly dose by 30% to 50%.
1.91–2.49	Increase weekly dose by 10% to 30%.
2.5–3.5	Keep same weekly dose.
3.51–4.5	Decrease weekly dose by 10% to 30%.
4.51–5.5	Decrease weekly dose by 30% to 50%. Consider holding 1 or 2 doses depending on bleeding risk.
>5.51	Decrease weekly dose by 40% to 60%. Hold 1 or 2 doses. Assess bleeding status and risk.

Figure 2: Revised warfarin dosing guidelines.

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INR increases too early after starting warfarin
OR
INR increases too much after starting warfarin

If INR increases by 0.5 after *any dose:*
Give only *half* dose recommended for INR.

If INR increases by >1 after *any single dose:*

1. Check for liver disease, drug interference, poor nutrition, vitamin K intake, diet, diarrhea, etc.
2. Give only one-quarter (25%) of the dose.

INR fails to increase
OR
INR increases too little according to the expected dose–response relation

If INR not >1.3 after 4 consecutive doses of 10 mg:

1. Check for ingestion of vitamin K (e.g., nutrition supplements, seaweed or ethnic food, kale, proprietary vitamins)
2. Crush tablet, dissolve in water, and watch patient swallow medication with a juice chaser.

If still no increase in INR after 24–48 h:
Use twice dose recommended, but check INR carefully.

If INR stops increasing after initial satisfactory response:
Check diet, drug, and compliance again.

Figure 2: Revised warfarin dosing guidelines (*continued from page 108).*

Table 1. Patient Characteristics

Characteristic	No. (and %) of Patients*	
	Old Protocol (n = 59)	New Protocol (n = 28)
Mean age (years)	62.1	60.6
Sex (no. and % male)	29 (49)	11 (39)
History of bleeding	3 (5)	0 (0)
Anticoagulation at admission	23 (39)	16 (57)
Hepatic dysfunction	1 (2)	0 (0)
Indication for warfarin		
Atrial fibrillation	31 (53)	15 (54)
Valve replacement	8 (14)	7 (25)
Left ventricular dysfunction	32 (54)	12 (43)
Myocardial infarction	15 (25)	8 (29)
Deep vein thrombosis or pulmonary embolism	1 (2)	2 (7)
Drug interactions†		
Acetylsalicylic acid	22 (37)	6 (21)
Amiodarone	19 (32)	6 (21)
Ciprofloxacin	1 (2)	5 (18)
Cotrimoxazole	0 (0)	1 (4)
Allopurinol	0 (0)	1 (4)

*Except where indicated otherwise.
†$p < 0.001$ for trend.

Patients were divided into 2 groups, depending on whether their dosage was determined according to the old or the new protocol. Consecutive patients whose dose was determined with the old protocol during a specific 4-month period were selected to audit the quality of the initial PAWD program. After the guidelines were revised, all consecutive patients enrolled in the PAWD program for the first 2 months after implementation of the new protocol were selected for the follow-up quality audit. Patient data were used to calculate and compare the mean daily warfarin dose, the proportion of cases for which the protocol was followed, the mean INR each day, the proportion of patients with therapeutic INR each day, and the range of INRs between the 2 groups. A therapeutic INR (1.8 to 3.2) was defined on the basis of the target INR for the majority of patients (2 to 3) with a margin of ±0.2 to account for variability in laboratory measurements. Continuous data were analyzed by means of *t*-tests, whereas categorical data were compared with the chi-square test. Statistical significance was defined as $p < 0.05$.

RESULTS OF QUALITY IMPROVEMENT PROCESS

Data for 59 patients who received warfarin therapy according to the old protocol were compared with data for 28 patients whose dosing followed the new protocol. Most of the baseline characteristics of the 2 groups were similar (Table 1). The numbers of drug interactions differed significantly ($p < 0.001$). Most of the patients were receiving anticoagulation with a target INR of 2 to 3 (old protocol, 51 [86%]; new protocol 21 [75%]). The most common indications for both groups included atrial fibrillation (old protocol, 31 [53%]; new protocol, 15 [54%]) with or without left ventricular dysfunction (old protocol, 32 [54%]; new protocol, 12 [43%]).

The mean daily warfarin doses (Figure 3) followed similar trends but were lower when the new protocol

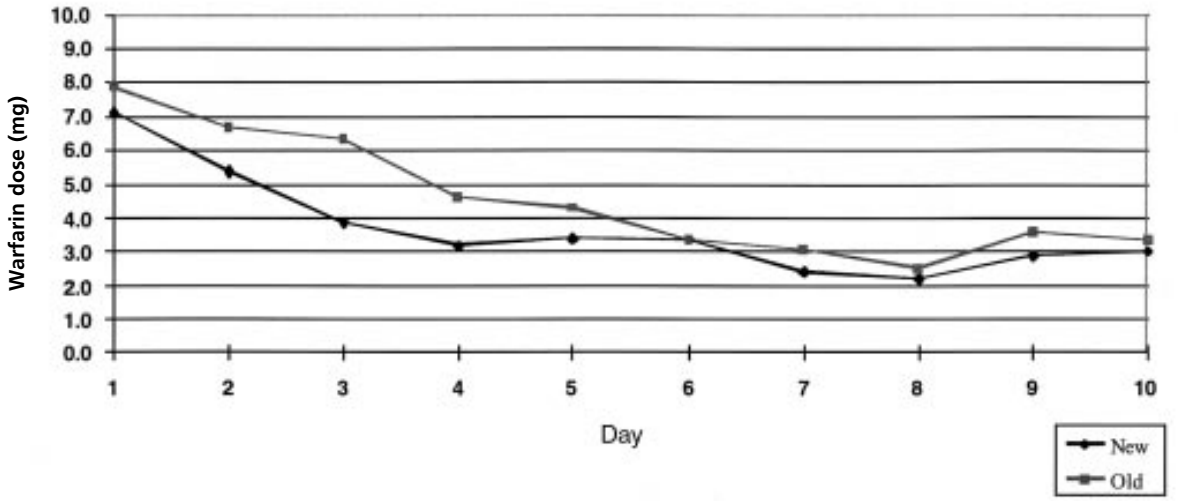

Figure 3. Daily warfarin doses according to new and old protocols.

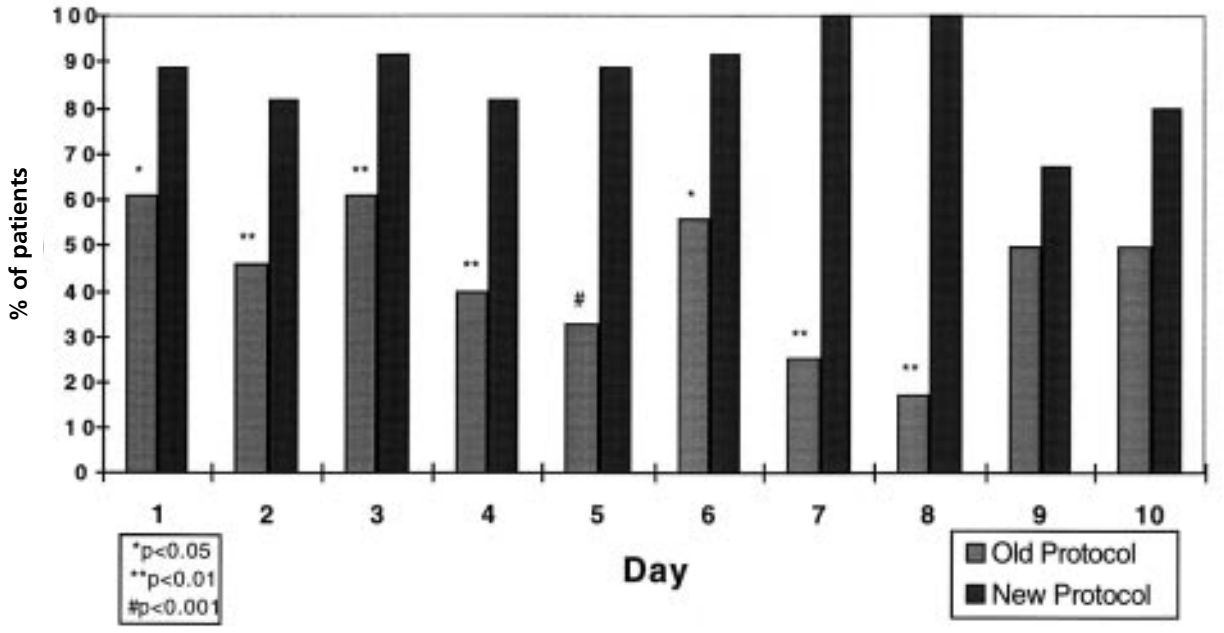

Figure 4. Proportion of patients for whom protocol was followed.

was used, especially during the first 5 days of therapy. The new protocol was followed in a larger proportion of patients (Figure 4). This difference was statistically significant from day 1 to day 8. The new protocol was being followed in more than 80% of cases. The proportion of patients with a therapeutic INR (1.8 to 3.2) was higher when the new protocol was used (Figure 5). The difference was significant on days 5 and 6. The mean number of days in the therapeutic range per patient was statistically significantly higher with the new protocol (p = 0.01) (Table 2).

DISCUSSION

The benefits of pharmacists' impact in the development, implementation, and management of anticoagulation services in both inpatient[9-13] and outpatient settings[13-16] have been documented in the literature. Positive outcomes from the implementation of such services have included improved determination of warfarin dose, improved stability of prothrombin time and INR, and fewer determinations of prothrombin time.[9] At The Toronto Hospital, the advantages of such

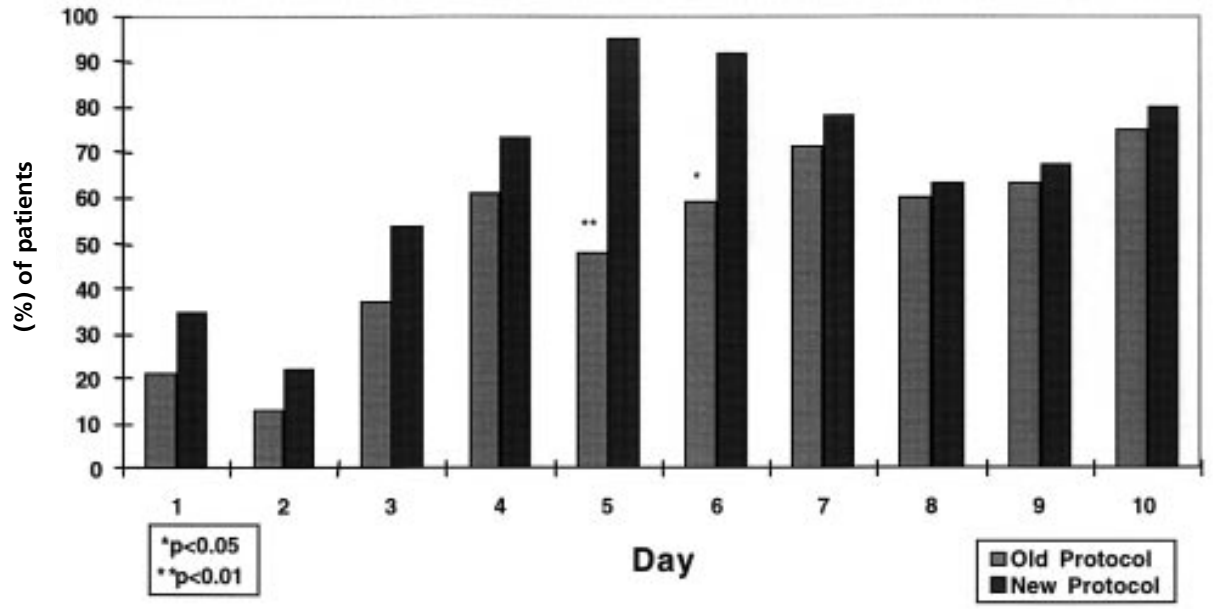

Figure 5. Proportion of patients with therapeutic international normalized ratio (1.8 to 3.2).

Table 2. Time within Therapeutic Range of International Normalized Ratio (INR)

	Mean ± SD (and Range)			
	Old Protocol		New Protocol	
No. of days of warfarin therapy	5.6 ± 2.3	(1–10)	5.8 ± 2.7	(2–10)
No. of days in therapeutic INR range*	2.3 ± 2.1	(0–9)	3.3 ± 2.6	(0–8)
Time in therapeutic INR range (%)	52.02 ± 38.51	(0–100)	62.14 ± 40.29	(0–100)
Time to therapeutic INR range (days)†	3.3 ± 1.6	(1–8)	2.9 ± 1.3	(1–5)

SD = standard deviation
*$p < 0.01$.
†$p = 0.15$.

a service were recognized. In 1994 the PAWD pilot project was successfully developed and implemented. The program was well received by nursing and medical staff. It achieved the effective and safe anticoagulation of patients. It also improved compliance and timely administration of warfarin doses.[2]

Given the successful implementation, the next step of the PDCA cycle, "Check," was vital to confirming the continuing benefits of the program. The use of a warfarin dosing protocol was central to the operation of the PAWD program. The original protocol was designed to provide a precise warfarin dose given a certain INR on days 1 to 5 (Figure 1). Doses were adjusted further if the increase in INR exceeded predetermined levels. If the pharmacist wished to exercise professional judgement and formulate a dose outside the protocol, the physician had to be contacted. The guidelines were less useful after day 5, as they were not designed for maintenance dose adjustment. These doses were determined by pharmacists from patient trends. Retrospective analysis of PAWD monitoring profiles revealed that for the first 59 patients, pharmacists followed the warfarin protocol only half the time. This led to inefficiencies in ordering doses. The protocol was modified to allow more flexibility in responding to specific patient scenarios. Lower dosage ranges could be selected for patients with interacting drugs or congestive heart failure. Dosages could also be reduced for patients with recent invasive procedures such as pacemaker insertion, in whom the potential for hematoma formation is a concern. Guidelines were also added for adjustment of maintenance doses (Figure 2).

Retrospective analysis revealed that the quality of the program had improved. The new protocol was being used more frequently than the old protocol. Increased flexibility in dosing made it more efficient for a pharmacist to write warfarin orders. In addition to increased efficiency, there were trends to a faster achievement of target INR (i.e., 2.9 days with the new protocol and 3.3 days with the old protocol). These trends could be expected to improve efficacy by decreasing the potential of a negative patient outcome

(e.g., thromboembolic event). A greater proportion of INRs were in the target range at days 5 and 6 with the new protocol (Figure 5). The lack of a significant difference for most of the days may have been due to the small size of the 2 groups. Although the proportion of new protocol patients with a therapeutic INR appeared to decrease after day 5, the average duration of treatment was 5.6 days (Table 2). The majority of patients who achieved therapeutic INRs by this time would likely have been discharged home. Thus patients in hospital after day 6 were probably those with other conditions delaying discharge. Anticoagulation may have been more difficult in these patients, which would have resulted in the lower proportions after day.[6]

Lower mean warfarin loading doses were used for patients in the new protocol group. No bleeding events occurred, and vitamin K was used only once. These findings are consistent with the recent literature, which supports use of lower (5-mg) loading doses.[17-19] With the old protocol, 3 patients experienced bleeding (2 had bruising, and 1 had gastrointestinal bleeding), and vitamin K was used twice. Overall, the frequency of adverse effects was low, and no thromboembolic events occurred with either protocol.

Some limitations of this study include the retrospective nature of the analysis and the low numbers. The reliance on pharmacist documentation and computerized medical and pharmacy patient records instead of a complete review of the medical chart is another weakness. Data for a concurrent control group for which warfarin dosing was determined by physicians were collected during the pilot study, but not during the quality audit study. It was assumed that physician prescribing had not changed from the initial pilot period.

A large proportion of the literature has been devoted to describing and assessing outcomes of outpatient anticoagulation programs.[10,11] In addition, guidelines have been developed for such outpatient programs, although there are no guidelines for inpatient programs. The PAWD program met many of the criteria set out in a 1998 consensus guideline developed for outpatient management of oral anticoagulation therapy.[20] Among these, the PAWD program incorporated an assessment of the appropriateness of anticoagulation, an assessment of relevant patient characteristics such as current medical and medication history, the establishment of a patient-specific INR range, the adjustment of doses on the basis of INR results, individual assessment of patient-specific response, and monitoring of patients during the initial and follow-up periods.

Ongoing continuous quality improvement measures are important components of the program. Data continue to be collected to assess program efficiency and effectiveness. Time efficiency is an ongoing concern. An informal survey of cardiac pharmacists who have experience with the program revealed that completion of all protocol procedures for the first warfarin dose (which includes a full consultation, patient interview, and documentation in the medical chart) took on average 22 min (range 15 to 40 min). The time required to determine subsequent doses and complete the necessary documentation, including writing the order in the medical chart, was approximately 7 min (range 2 to 10 min).

The program has now been fully implemented in the cardiology unit. Implementation is being considered for the vascular surgery unit. Expansion of the pharmacist's role in ordering vitamin K for reversal of anticoagulation is being considered. Currently the pharmacist must contact the physician if reversal of anticoagulation is required. Patient awareness of and satisfaction with pharmacist involvement within this program is another area for future assessment.

A mechanism for further tailoring of the warfarin protocol is in progress. Effective computer models[21,22] have been developed for determination of warfarin doses, but such systems are not readily accessible, are not well known to most pharmacists, and essentially represent a "black box" method of prescribing, one that may not incorporate all pertinent patient factors. The new protocol strikes a good balance. Pharmacists have found it effective, flexible, easily accessible, portable, and user-friendly.

In conclusion, the PAWD quality improvement initiative was successfully implemented. Use of the new warfarin dosing protocol resulted in a larger proportion of INRs in the target range than was the case with the original protocol. Pharmacists found the modified warfarin protocol more user-friendly than the old protocol. It allowed greater use of professional judgement while balancing the legal responsibility of dependent prescribing under protocol.

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