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# Implementation and Evaluation of a Warfarin Dosing Service for Rehabilitation Medicine: Report from a Pilot Project

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## ABSTRACT

**Background:** Surgical patients requiring complex care are routinely referred from acute care sites to rehabilitation hospitals. Before 2003, Providence Healthcare, a rehabilitation centre in Toronto, Ontario, had no anticoagulation service.

**Objectives:** To report the results of a pilot project conducted preparatory to establishing a pharmacy-directed warfarin service.

**Methods:** A 5-month pilot project for a new pharmacy-directed warfarin service (provided by a certified anticoagulation pharmacist) was conducted from mid-October 2003 to mid-March 2004. Chart reviews were conducted for 2 retrospective control groups: 42 patients who received baseline warfarin dosing by rehabilitation physicians in 2002 and 33 patients who received warfarin dosing by rehabilitation physicians in 2003–2004 (concurrent with the pilot project). Therapy for control patients was instituted without use of warfarin nomograms or anticoagulation training.

**Results:** Thirty-three patients were recruited from one rehabilitation unit for participation in the pilot project. Patients in the pilot project reached therapeutic international normalized ratio (INR) levels more quickly than patients in the baseline control and concurrent control groups (2.8, 5.3, and 3.0 days, respectively). The proportion of INR results within the therapeutic range was greater for patients in the pilot project than for patients in the baseline control and concurrent control groups (67.9%, 44.2%, and 50.9%, respectively) and the proportions of subtherapeutic (22.7%, 46.6%, and 33.2%, respectively) and supratherapeutic (9.4%, 9.2%, and 14.9%, respectively) results were lower (or similar) among patients in the pilot project relative to the controls. No patients in the pilot project group or concurrent control group required vitamin K or fresh frozen plasma; 2 patients in the baseline control group required a total of 5 vitamin K doses. Among patients in the pilot project, there were no new diagnoses of deep vein thrombosis, pulmonary embolism, or cerebrovascular accident, and no deaths; in contrast, there were 2 cases of pulmonary embolism and 3 episodes of major bleeding among the patients in the baseline control and concurrent control groups.

**Conclusion:** The pilot project for the pharmacy anticoagulation service was deemed successful and could be expanded to all rehabilitation units within the authors' institution.

## RÉSUMÉ

**Historique :** Les opérés qui nécessitent des soins complexes sont systématiquement dirigés des établissements de soins de courte durée vers des centres de réadaptation. Avant 2003, Providence Healthcare, un centre de réadaptation de Toronto, en Ontario, ne possédait pas de service d'anticoagulothérapie.

**Objectifs :** Faire état des résultats d'un projet pilote devant éventuellement mener à la mise sur pied d'un service d'administration de warfarine dirigé par la pharmacie.

**Méthodes :** Un projet pilote d'une durée de cinq mois pour un nouveau service de surveillance de la warfarine dirigé par la pharmacie (fourni par un pharmacien agréé en anticoagulothérapie) a été mené entre octobre 2003 et mars 2004. Une analyse rétrospective des dossiers médicaux a été réalisée sur deux groupes témoins : un groupe de référence de 42 patients dont la dose a été établie par des médecins spécialisés en réadaptation en 2002 et un groupe simultané de 33 patients dont la dose de warfarine a aussi été établie par des médecins spécialisés en réadaptation en 2003 et 2004 durant le projet pilote. Le traitement des patients témoins a été établi sans que les médecins n'aient utilisé de nomogrammes pour la warfarine ni eu de formation en anticoagulothérapie.

**Résultats :** On a recruté 33 patients d'une unité de réadaptation pour participer au projet pilote. Un rapport international normalisé (RIN) à l'intérieur des valeurs thérapeutiques a été atteint plus rapidement chez les patients du groupe projet pilote que chez les patients du groupe de référence et ceux du groupe simultané (2,8, 5,3 et 3,0 jours, respectivement). La proportion des résultats du RIN à l'intérieur de l'écart thérapeutique était supérieure chez les patients du groupe projet pilote que chez ceux du groupe de référence et du groupe simultané (67,9 %, 44,2 % et 50,9 %, respectivement) et les proportions de résultats sous-thérapeutiques (22,7 %, 46,6 % et 33,2 %, respectivement) et suprathérapeutiques (9,4 %, 9,2 % et 14,9 %, respectivement) étaient inférieures (ou similaires) chez les patients du groupe projet pilote comparativement à celles des deux groupes témoins. Aucun patient du groupe projet pilote ni du groupe simultané n'a eu besoin de vitamine K ou de plasma frais congelé; deux patients dans le groupe de référence ont nécessité un total de cinq doses de vitamine K. Aucun nouveau cas de thrombose veineuse

**Key words:** anticoagulation, international normalized ratio, rehabilitation medicine, warfarin

profonde, d'embolie pulmonaire ou d'accident vasculaire cérébral ni de mortalité n'a été signalé chez les patients du groupe projet pilote, contrairement aux deux groupes témoins où l'on a signalé deux cas d'embolie pulmonaire et trois épisodes d'hémorragie grave.

**Conclusion :** Le projet pilote de service d'anticoagulothérapie dirigé par la pharmacie a été une réussite et pourrait être étendu à toutes les unités de réadaptation au sein de l'établissement de santé où exercent les auteurs.

**Mots clés :** anticoagulation, rapport international normalisé, médecine de réadaptation, warfarine

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## INTRODUCTION

Patients are routinely referred from acute care sites to rehabilitation hospitals for subacute care and transition into the community. Providence Healthcare is a Toronto health care facility specializing in rehabilitation for patients who have experienced strokes, orthopedic surgery, and lower limb amputation. Services include complex continuing care, long-term care, and community outreach, with a particular emphasis on the clinical treatment and care of elderly patients. One of the Providence Healthcare sites, Providence Hospital (where the study reported here took place) is the third-largest rehabilitation and complex continuing care hospital in Ontario, with 338 beds.

The care required by rehabilitation patients is often complex; for example, elderly patients who have undergone orthopedic surgery may also require the expertise of an interdisciplinary team, including geriatricians and specialists in anticoagulation management, to prevent venous thromboembolism and/or arterial thrombosis (i.e., stroke).[1,2] The major problems encountered in preventive antithrombotic care are lack of warfarin expertise among physicians, nurses, and pharmacists; subtherapeutic dosing; inconsistent laboratory monitoring; and fragmented care.[3] For over 20 years, anticoagulation clinics and services in Ontario, Quebec, and the United States have provided safer and more effective preventive antithrombotic care than traditional warfarin management under the supervision of family physicians.[3-23]

As is the case for many health care facilities in North America, Providence Healthcare had no warfarin dosing or anticoagulation management service. In early 2002, the institution's Medical Advisory Committee identified the need to improve warfarin management. There was strong support from the medical, nursing, and administrative staff for a pharmacy-directed warfarin dosing service, and a proposal from the pharmacy department for a warfarin dosing service was approved in June 2002 by the Pharmacy and Therapeutics Committee for implementation as a pilot project.

The goals and objectives for the warfarin dosing service were to provide effective and safe anticoagulation therapy by achieving and maintaining therapeutic international normalized ratio (INR) quickly and safely; to improve the consistency of warfarin dosing, especially during weekends and statutory holidays; to improve patient outcomes and increase patient safety; to decrease errors in warfarin dosing; to ensure that patients' current and past medical history, medication history, and drug–food interactions were evaluated before a dose recommendation; and to decrease the frequency of INR testing.

This article reports an evaluation of a pilot project conducted preparatory to establishing a pharmacy-directed warfarin service at Providence Healthcare.

## METHODS

An evaluation of the pilot project was conducted as an open case series. The aim was to enroll 30 patients in the pilot warfarin dosing service over a 5-month study period (October 16, 2003, to March 18, 2004).

All patients admitted to a single rehabilitation unit handling orthopedic, amputation, and stroke rehabilitation (unit B2R [known in 2002 as 5AR and 3BR]) were eligible for referral to the warfarin dosing service during the study period. Patients were excluded if their admission lasted for less than 24 h and/or they received less than 24 h of warfarin therapy. A single certified anticoagulation pharmacist (T.C.) was primarily responsible for providing the service during the study period, as recommended by consensus guidelines.[24] During any absences, a second clinical pharmacist (M.M.L.) provided coverage. Patients' warfarin therapy was categorized as

follows: initiation (first dose of warfarin provided on the rehabilitation unit; no warfarin before admission to the rehabilitation unit), maintenance (stable warfarin dosages and INR results before and during admission to the rehabilitation unit), and transition (fluctuating warfarin dosages and INR results before and during the admission).[20,22]

The warfarin protocol, dosing nomograms, policies, and procedures for the pilot project were adapted from those of the Lakeridge Health Corporation, Oshawa, Ontario, and were approved by the Pharmacy and Therapeutics Committee and the Medical Advisory Committee of Providence Healthcare in 2002. During the study period, INR samples were obtained by venipuncture and were processed (and the results reported) by off-site laboratory services.

All bleeding events were classified by severity. Minor bleeding was defined as bleeding that did not require specific medical intervention to stop the bleeding, such as nose bleeds and small hematomas.[24-27] Major bleeding was defined as bleeding for which specific medical interventions, hospital observation for more than 24 h, or significant diagnostic testing were required and/or bleeding that might have been fatal or life-threatening without medical attention.[24-27] Life-threatening bleeding events were defined as fatal events, those occurring intracranially or in other sites where they were potentially lethal, those associated with cardiopulmonary arrest or hypotension, and those requiring major interventions such as surgery or angiography.[24-27]

Chart reviews were conducted for 2 retrospective control groups: baseline warfarin dosing by rehabilitation physicians in 2002 (the baseline control group) and warfarin dosing by rehabilitation physicians in 2003–2004 (during the period of the pilot project; the concurrent control group). For the baseline control group, the Medical Records Department randomly selected charts for review from patients admitted to the rehabilitation unit between March 11, 2002, and July 11, 2002. For the concurrent control group, the first 33 patients receiving warfarin who were admitted to units other than unit B2R during the study period (mid-October 2003 to mid-March 2004) and who met the inclusion criteria (i.e., admission to the rehabilitation unit and warfarin therapy for more than 24 h) were automatically enrolled. Figure 1 shows an overview of the timeline for the 3 study groups.

The control groups yielded information on traditional warfarin management (without protocols or nomograms), details of warfarin dosing by physicians, and other similar data.

A 6-month postintervention observation period (March 19, 2004, to September 18, 2004) was planned to evaluate patient outcomes after discharge. An anticoagulation and research consultant (W.A.L.) was hired to assist with implementation, evaluation, and reporting of the pilot project. Data were collected by 2 investigators (including T.C.) and reviewed by 2 other investigators (W.A.L., M.R.). Data entry and analysis were conducted

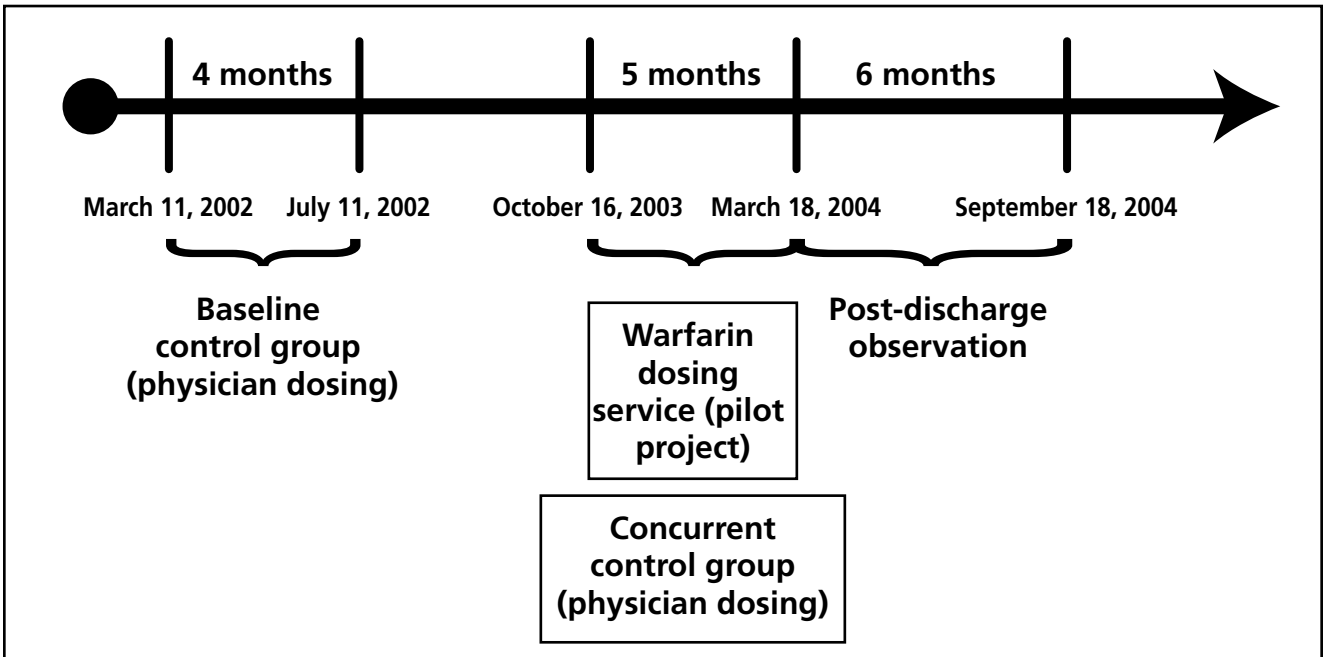


**Figure 1.** Overview of the timelines for the baseline control, concurrent control, and pilot project groups.

with Excel version 5.0 (Microsoft, Seattle, Washington). No statistical tests were performed.

## RESULTS

### Hospital Administrators' Concerns

The rehabilitation program director (M.R.) and the facility's vice-president were interviewed in February 2004, near the end of the pilot project. At that time, they reported the following reasons for establishing a warfarin dosing service: inconsistent warfarin dosing and monitoring at the institution; lack of familiarity with patients and inconsistent coverage by on-call physicians on weekends and statutory holidays; high volume of patients receiving warfarin therapy referred from acute care facilities; no standardized protocol for prevention of deep vein thrombosis (DVT) and no policy for discontinuing anticoagulation (including low-molecular-weight heparin [LMWH]); no on-site anticoagulation expertise; lack of laboratory services on weekends and statutory holidays; a desire to build and expand pharmacists' scope of practice; a desire to delegate anticoagulation resources from physicians to pharmacists; greater physician support for pharmacy and patients; increased length of stay because of delayed anticoagulation; and desire for physician and staff education.

### Data for Baseline Control Group (2002)

The pilot project was originally planned to start in September 2002, so the baseline physician dosing data were collected from March 11, 2002, to July 11, 2002. The purpose of collecting these data was to establish the need for a warfarin dosing service and to characterize physician warfarin management, both within the rehabilitation unit and throughout the hospital.

The charts for 42 patients treated in the rehabilitation unit were randomly selected by the Medical Records Department and reviewed by one clinical pharmacist (T.C.). This group included substantially more women than men (34 and 8, respectively) with an overall mean age of 71.6 years, a mean weight of 71.4 kg, and a history of cardiovascular disease (17% of patients), gastrointestinal disease, including pelvic ulcer disease (14%), and DVT or pulmonary embolism (7%) (Table 1). The primary reason for admission was rehabilitation after major orthopedic surgery, and the mean length of the hospital stay was 27.2 days.

Warfarin had been initiated (at acute care facilities) a mean of 11.5 days before admission to the rehabilitation unit (Table 2). Warfarin was most often prescribed for DVT prophylaxis. Thirty-five patients (83%) were undergoing transition dosing.

During the baseline period, there were a total of 425 warfarin orders, or 10.9 orders per patient, and the mean duration of warfarin therapy was 26.9 days. Patients in the baseline control group were receiving an average of 11.3 concurrent medications (Table 2). The most common interactions with other drugs involved

**Table 1. Characteristics of Patients in Baseline Control Group***

| Characteristic | No. (%) of Patients or Mean (Range) | |
|---|---|---|
| No. of patients | 42 | |
| Age (yr) | 71.6 | (52–92) |
| Sex | | |
| Men | 8 | (19) |
| Women | 34 | (81) |
| Body weight (kg) | 71.4 | (42.9–117.6) |
| Length of stay (days) | 27.2 | (6–57) |
| Reason for rehabilitation | | |
| Orthopedic surgery | 41 | (98) |
| Amputation | 1 | (2) |
| Medical history | | |
| Deep vein thrombosis or pulmonary embolism | 3 | (7) |
| Cardiovascular disease† | 7 | (17) |
| Gastrointestinal disease or peptic ulcer disease | 6 | (14) |
| Cancer | 1 | (2) |

*Patients were selected at random from those treated during the period March 11, 2002, to July 11, 2002.
†Coronary artery disease, ischemic heart disease, cerebrovascular accident.

**Table 2. Warfarin Use Before and During Admission for Patients in Baseline Control Group (*n* = 42)**

| Characteristic of Therapy | No. (%) of Patients or Mean (Range) | |
|---|---|---|
| Duration of warfarin therapy before admission (days) | 11.5 | (1–31) |
| Duration of warfarin therapy on unit (days) | 26.9 | (6–57) |
| Indication for warfarin | | |
| DVT prophylaxis | 40 | (95) |
| DVT treatment | 2 | (5) |
| Type of warfarin therapy* | | |
| Initiation | 1 | (2) |
| Maintenance | 6 | (14) |
| Transition | 35 | (83) |
| No. of medications during admission | 11.3 | (5–20) |
| No. of warfarin interactions during admission | 1.5 | (1–4) |
| No. of orders for warfarin during admission† | 425 | (10.9/patient) |

DVT = deep vein thrombosis.
*Initiation = first dose of warfarin provided on the rehabilitation unit, with no warfarin before admission to the rehabilitation unit; maintenance = stable warfarin dosages and international normalized ratio (INR) before and during admission to the rehabilitation unit; transition = fluctuating warfarin dosages and INR results before and during the admission.
†Presented as total number and mean per patient.

acetaminophen (all 42 patients or 100%), antibiotics (13 patients or 31%), statins (5 patients or 12%), and LMWH (2 patients or 5%).

The mean baseline INR was subtherapeutic (1.90), but the results for individual patients ranged from subtherapeutic to supratherapeutic (1.10 to 5.10) (Table 3). On average, 11.3 INR results were obtained for each patient during the hospital stay, and it took on average 5.3 days to reach the first therapeutic INR.

For each patient, an average of 44.2% of INR results were within the therapeutic range, 46.6% were subtherapeutic, and 9.2% were supratherapeutic (Table 3). Vitamin K was required a total of 5 times (for 2 patients).

One patient had a nonfatal pulmonary embolism, and another had a major bleeding episode (hematuria, INR = 7.7). There were no deaths in the baseline control group.

## Data Obtained during Pilot Project for Rehabilitation Warfarin Dosing Service (2003–2004)

A total of 33 patients were followed through the pilot project for the rehabilitation warfarin dosing service during the 5-month study period. A group of 33 patients who underwent physician dosing on other units during this period served as the concurrent control group. Tables 5 to 8 compare results for the concurrent control group with those of the patients treated through the warfarin dosing service (pilot project group).

The concurrent control group had fewer women than the pilot project group, a similar mean age but a greater age range, and similar body weight (Table 5). In both groups, the primary reason for admission was rehabilitation after major orthopedic surgery. Slightly more patients in the pilot project group had cardiovascular disease, and more of these patients had a history of gastrointestinal problems. The mean duration of the hospital stay was 22.2 days for the concurrent control group and 26.9 for the pilot project group.

Warfarin therapy at acute care facilities before admission to the rehabilitation unit was of shorter duration among patients in the concurrent control group than among those in the pilot project group (8.4 and 12.9 days, respectively) (Table 6), and mean duration of warfarin therapy in the rehabilitation unit was also shorter for patients in the concurrent control group (22.2 and 26.9 days, respectively). In both groups, the most common indication for warfarin was DVT prophylaxis.

In terms of warfarin management, most patients in both the concurrent control group and the pilot project group were receiving transition dosing (Table 6). Physician dosing in the concurrent control group was associated with a mean of 9.9 warfarin orders per patient, whereas dosing through the pilot project was associated with 9.3 orders per patient (Table 6). The number of concurrent medications was similar in the 2 groups (12.8 and 13.6 in the concurrent control and pilot project groups, respectively), and patients in each group had a mean of 2.4 drug interactions during the hospital stay. The most common drug interactions were acetaminophen (30 [91%] of patients in the concurrent control group and 26 [79%] of those in the pilot project group), statins (10 [30%] and 9 [27%]), and antibiotics (7 [21%] and 7 [21%]).

Mean baseline INR on admission was therapeutic in the 2 groups, with a range from subtherapeutic to supratherapeutic (Table 7). The number of INR results obtained per patient during the hospital stay was similar (9.9 and 9.3), and the time to reach the first

**Table 3. INR Results for Patients in Baseline Control Group (*n* = 42)***

| Variable | Mean (Range) | |
|---|---|---|
| Baseline INR on admission† | 1.90 | (1.10–5.10) |
| No. of INR results during hospital stay | 11.3 | (3–29) |
| Time to reach first therapeutic INR (days) | 5.3 | (1–20) |
| INR value (% of results while receiving warfarin) | | |
| Therapeutic (2.0–3.0) | 44.2 | (12.5–85.7) |
| Subtherapeutic (< 2.0) | 46.6 | (20.0–71.4) |
| Supratherapeutic (3.01–3.99) | 7.7 | (0–40.0) |
| Supratherapeutic (4.0–6.0) | 1.1 | (0–16.7) |
| Supratherapeutic (> 6.0) | 0.4 | (0–7.7) |
| Total no. of vitamin K doses | 5‡ | |
| No. of times FFP given | 0 | |

INR = international normalized ratio, FFP = fresh frozen plasma.
*Target value 2.0–3.0 (appropriate for deep vein thrombosis prophylaxis).
†For patients receiving warfarin.
‡For a total of 2 patients

**Table 4. Outcomes for Patients in Baseline Control Group (*n* = 42) ***

| Characteristic | No. (%) of Patients | |
|---|---|---|
| New diagnosis (during admission) | | |
| Deep vein thrombosis | 0 | |
| Pulmonary embolism | 1 | (2) |
| Cerebrovascular accident | 0 | |
| Death (warfarin-related or not) | 0 | |
| Hemorrhagic events | | |
| Minor | 0 | |
| Major* | 1 | (2) |
| Life-threatening | 0 | |

*Hematuria (INR = 7.7).

**Table 5. Characteristics of Patients in Concurrent Control Group and Patients Receiving Warfarin Dosing Service (Pilot Project Group)***

| Characteristic | No. (%) of Patients or Mean (Range) | | | |
|---|---|---|---|---|
| | Concurrent Control (Physician Dosing) | | Warfarin Dosing Service | |
| No. of patients | 33 | | 33 | |
| Age (yr) | 71 | (34–96) | 72 | (47–88) |
| Sex | | | | |
| Men | 8 | (24) | 6 | (18) |
| Women | 25 | (76) | 27 | (82) |
| Body weight (kg) | 68.7 | (36.0–118.1) | 70.5 | (47.3–111.1) |
| Length of stay (days) | 22.2 | (4–70) | 26.9 | (5–94) |
| Reason for rehabilitation | | | | |
| Orthopedic surgery | 31 | (94) | 32 | (97) |
| Amputation | 2 | (6) | 1 | (3) |
| Medical history | | | | |
| Deep vein thrombosis or pulmonary embolism | 3 | (9) | 4 | (12) |
| Cardiovascular disease† | 13 | (39) | 14 | (42) |
| Gastrointestinal disease or peptic ulcer disease | 6 | (18) | 12 | (36) |
| Cancer | 3 | (9) | 2 | (6) |

*Patients in the concurrent control group were treated on other units during the period of the pilot project (October 16, 2003, to March 18, 2004).
†Coronary artery disease, ischemic heart disease, cerebrovascular accident.

**Table 6. Warfarin Use Before and During Admission for Concurrent Control and Pilot Project Groups**

| Characteristic | No. (%) of Patients or Mean (Range) | | | |
|---|---|---|---|---|
| | Concurrent Control (Physician Dosing) (*n* = 33) | | Warfarin Dosing Service (*n* = 33) | |
| Duration of therapy before admission (days) | 8.4 | (3–20) | 12.9 | (5–49) |
| Duration of warfarin therapy on unit (days) | 22.2 | (4–70) | 26.9 | (5–94) |
| Indication for warfarin | | | | |
| Atrial fibrillation | 5 | (15) | 4 | (12) |
| DVT prophylaxis | 27 | (82) | 27 | (82) |
| DVT treatment | 1 | (3) | 2 | (6) |
| CVA prophylaxis | 6 | (18) | 3 | (9) |
| Type of warfarin therapy* | | | | |
| Initiation | 0 | | 0 | |
| Maintenance | 6 | (18) | 5 | (15) |
| Transition | 27 | (82) | 28 | (85) |
| No. of medications during admission | 12.8 | (6–19) | 13.6 | (6–23) |
| No. of warfarin interactions during admission | 2.4 | (1–4) | 2.4 | (1–4) |
| No. of orders for warfarin during admission† | 328 | (9.9) | 308 | (9.3) |

DVT = deep vein thrombosis, CVA = cerebrovascular accident.
*Initiation = first dose of warfarin provided on the rehabilitation unit, with no warfarin before admission to the rehabilitation unit; maintenance = stable warfarin dosages and international normalized ratio (INR) before and during admission to the rehabilitation unit; transition = fluctuating warfarin dosages and INR results before and during the admission.
†Presented as total number (and mean per patient).

**Table 7. INR Results for Concurrent Control and Pilot Project Groups***

| Characteristic | Mean (Range) | | | |
|---|---|---|---|---|
| | Concurrent Control (Physician Dosing) (*n* = 33) | | Warfarin Dosing Service (*n* = 33) | |
| Baseline INR on admission† | 2.24 | (1.05–3.90) | 2.19 | (1.22–3.98) |
| No. of INR results during hospital stay | 9.9 | (1–31) | 9.3 | (3–23) |
| Time to reach first therapeutic INR (days) | 3.0 | (0–14) | 2.8 | (0–10) |
| INR value (% of results while receiving warfarin) | | | | |
| Therapeutic (2.0–3.0) | 50.9 | (0–100) | 67.9 | (0–100) |
| Subtherapeutic (< 2.0) | 33.2 | (0–100) | 22.7 | (0–100) |
| Supratherapeutic (3.01–3.99) | 12.8 | (0–50) | 9.1 | (0–50) |
| Supratherapeutic (4.0–6.0) | 2.1 | (0–20) | 0.3 | (0–11.1) |
| Supratherapeutic (> 6.0) | 0 | | 0 | |
| Total no. of vitamin K doses | 0 | | 0 | |
| No. of times FFP given | 0 | | 0 | |

INR = international normalized ratio, FFP = fresh frozen plasma.
*Target value 2.0–3.0 (appropriate for deep vein thrombosis prophylaxis).
†For patients receiving warfarin.

**Table 8. Outcomes for Concurrent Control and Pilot Project Groups**

| Characteristic | No. (%) of Patients | | | |
|---|---|---|---|---|
| | Concurrent Control (Physician Dosing) (*n* = 33) | | Warfarin Dosing Service (*n* = 33) | |
| New diagnosis (during admission) | | | | |
| Deep vein thrombosis | 0 | | 0 | |
| Pulmonary embolism | 1* | (2) | 0 | |
| Cerebrovascular accident | 0 | | 0 | |
| Death | | | | |
| Related to warfarin therapy | 1* | (2) | 0 | |
| Not related to warfarin therapy | 0 | | 0 | |
| Hemorrhagic events | | | | |
| Minor | 2† | (6) | 1‡ | (3) |
| Major | 2§ | (6) | 0 | |
| Life-threatening | 0 | | 0 | |

*The pulmonary embolism occurred in the patient who died.
†Decrease in hemoglobin to 79 g/L (1 patient), hematoma (1 patient).
‡Hematoma related to venipuncture.
§Hematoma requiring draining (1 patient), rectal bleeding (1 patient).

therapeutic INR was about 3 days in each group. The proportion of INR results within the therapeutic range was lower in the concurrent control group than in the pilot project group (50.9% and 67.9%, respectively); conversely, greater proportions of INR results were subtherapeutic (33.2% and 22.7%) and supratherapeutic (14.9% and 9.4%) (Table 7). No vitamin K or fresh frozen plasma (FFP) was required for patients in either group.

Within the concurrent control group, 1 patient experienced fatal pulmonary embolism, 2 patients experienced minor bleeding, and 2 patients experienced major bleeding (Table 8). In contrast, the only adverse outcome in the pilot project group was minor bleeding in 1 patient (Table 8).

## Clinical Pharmacy Interventions during the Pilot Project

The new warfarin dosing service required physician referrals and clinical pharmacy resources. Clinical pharmacy interventions during the pilot project included warfarin dosage adjustments, INR monitoring (ordering and follow-up), identification and management of drug interactions, and patient education[20] (Table 9).

**Table 9. Clinical Pharmacy Interventions for Pilot Project Group (*n* = 33)***

| Intervention | Result |
|---|---|
| Adjustments to warfarin dosing | |
| Total no. and range | 308 (1–31) |
| Mean per patient | 9.3 |
| Mean no. (and range) of INR monitoring activities per patient (orders, follow-up) | 9.3 (3–23) |
| Mean no. (and range) of drug interctions identified and managed per patient† | 2.2 (1–4) |
| Patient education sessions‡ | |
| Total no. and range | 83 (1–5) |
| Mean per patient | 2.5 |
| Clinical pharmacist's time for new patient | |
| Initial patient interview | 10–20 min per patient |
| Monitoring forms | 10–20 min per patient |
| Clinical pharmacist's daily time for routine follow-up (for 1–10 patients) | |
| Reporting INR results | 4–48 min daily total |
| Follow-up patient interviews | 5–45 min daily total |
| Documentation and computer entry | 2–30 min daily total |
| Writing warfarin orders | 5–16 min daily total |
| Total time (for 1–10 patients) | 16–139 min daily total |

INR = international normalized ratio.
*Certified anticoagulation pharmacist was available at all times (either on site or on call for evenings, weekends, and holidays).
†Top drug interactions: acetaminophen (26 patients, 79%), statins (9 patients, 27%), allopurinol (2 patients, 6%), antibiotics (7 patients, 21%).
‡Patient education sessions included warfarin counselling; INR monitoring; interactions between warfarin and other drugs, diet, and lifestyle; signs and symptoms of bleeding.

Several of these activities can be considered as constituting risk management: routine surveillance for signs and symptoms of bleeding and/or thromboembolism, identification and management of interactions between warfarin and other drugs, and achievement and maintenance of therapeutic INR results as quickly and safely as possible.[28-31] The drugs most frequently involved in interactions with warfarin were acetaminophen, statins, allopurinol, and antibiotics, all of which have a tendency to increase INR and decrease the warfarin requirements.[1]

The clinical pharmacist (T.C.) provided 83 predischarge episodes of patient education for the 33 patients in the pilot project group (Table 9). Examples of counselling included warfarin education; interactions of warfarin with other drugs, diet, and lifestyle; and signs and symptoms of bleeding.[32]

Clinical pharmacy services were available at all times, either during regular hours or on an on-call basis (evenings, weekends, and statutory holidays). The total daily time required for the warfarin service ranged from 16 to 150 minutes (for 1 to 10 patients).

The clinical pharmacist's time was spent doing the work-up for new patients and performing routine follow-up for patients in the pilot project (Table 9). Work-up for a new patient involved completing the patient monitoring form and performing an initial patient interview, for a total of 20 to 40 minutes per new patient (Table 9). Routine follow-up included following up on INR results, conducting follow-up interviews with patients, performing documentation and computer entry, and writing warfarin orders, for a total of 16 to 139 minutes daily (for up to 10 patients).

## DISCUSSION

Previous studies throughout North America have yielded strong evidence that inpatient and outpatient warfarin dosing services and clinics staffed by qualified personnel are associated with better patient outcomes and anticoagulation management.[3-22] This study was performed to determine whether a pilot project at Providence Healthcare would support a hospital-wide inpatient warfarin dosing service.

The goals and objectives for the warfarin dosing service, listed above, were met during the 5-month period of the pilot project. Anticoagulation therapy provided during the pilot project was safe and effective, as indicated by maintenance of the INR within the therapeutic range for most INR tests, lower frequency of negative outcomes, and prevention of DVT and pulmonary embolism.

### Qualified Personnel

The 12 consensus guidelines of the Anticoagulation Guidelines Task Force indicate that qualified personnel in anticoagulation management may be physicians, nurses, pharmacists, or other health care professionals who have completed specialized anticoagulation training, education, and certification.[3] This group strongly recommends that providers of anticoagulation care have the Certified Anticoagulation Care Provider (CACP) designation, currently available only in the United States.[3,24]

Since 2002, a 4-day anticoagulation workshop for clinical pharmacists has been available in Canada for warfarin training, education, and certification.[33] The workshop contains 7 modules with content similar to the CACP material.[33] Participants receive a certificate of completion after passing a 4-h written exam. As of June 2004, 6 pharmacists at Providence Healthcare had been certified and available to provide hospital-wide warfarin management; these pharmacists report to an on-site medical supervisor when needed.[33]

## Similarities among the Study Groups

Data for the 3 study groups (2 control and 1 intervention) showed that Providence Healthcare routinely admitted patients for rehabilitation after orthopedic surgery. These elderly, primarily female patients had a higher risk of thromboembolism and/or bleeding because of concurrent diseases, polypharmacy, prolonged hospital stay, and other factors, and were similar to study groups described elsewhere.[28,34,35] Warfarin management required about 10 INR tests per patient, and about 11% of these tests indicated supratherapeutic INR (i.e., increased risk of bleeding). Clearly, anticoagulation management must be a high priority at this institution. These results support a standardized warfarin dosing service. The 3 study groups showed similar characteristics:

- warfarin therapy before admission in most patients (mean duration 11 days)
- warfarin primarily for DVT prophylaxis
- primarily transition dosing (i.e., fluctuating warfarin doses and INR results because of various factors such as drug interactions)
- mean of 2 interactions with other drugs (usually acetaminophen, statins, or antibiotics)
- target INR 2.0–3.0 for all patients
- no readmissions to Providence Healthcare for DVT, pulmonary embolism, or cerebrovascular accident (as of March 2004)

## Favourable Results with Warfarin Dosing Service

The warfarin dosing service was safer and more effective than dosing provided by physicians, for both the baseline and concurrent control groups. The limitations of the evaluation of the warfarin dosing service were the small sample size (33 patients), the short study period (5 months), the fact that there was only 1 certified anticoagulation pharmacist at the time of the pilot project, and the lack of a statistical analysis (i.e., the observed differences may have been due to chance).

The warfarin dosing service was associated with slightly fewer warfarin orders than the control groups; a slightly faster time to therapeutic INR; a greater proportion of INR results within the therapeutic range; lower proportions of subtherapeutic and supratherapeutic INR results; fewer adverse outcomes; no use of vitamin K or fresh frozen plasma; no new diagnoses of DVT, pulmonary embolism, or cerebrovascular accident; and no deaths.

The warfarin dosing service started on October 16, 2003, was a pilot project — a service new to the institution and to its physicians, nurses, and pharmacists. Therefore, as with any new service, it was to be expected that additional time would be required to learn the protocols and provide the services. With experience and greater patient numbers, efficiencies in the delivery of the service may be expected.[20]

## Less Favourable Results for the Control Groups

The 2 control groups (baseline and concurrent) showed less favourable patient outcomes. Physicians performing warfarin dosing for the 2 control groups did not have the benefits of warfarin nomograms, protocols, or specific training. Increased morbidity and mortality were reported (Tables 4 and 8).

The higher morbidity and mortality in the control groups are consistent with the literature.[10,13,17,28,29] Warfarin is one of the most complex drugs prescribed worldwide,[28,30,31,35] because of the need for individualized dosing and monitoring and its narrow therapeutic range. Optimal DVT prophylaxis and anticoagulation management continues to be a challenge for most health care facilities in North America.[1,3,25,28,36–41]

## Advantages of the Rehabilitation Warfarin Dosing Service

The goals and objectives for the warfarin dosing service were met during the 5-month pilot project. This evaluation clearly showed several advantages of the new service:

- effective and safe anticoagulation therapy (indicated by achievement and maintenance of therapeutic INR results)
- fewer negative patient outcomes (e.g., hemorrhage, thromboembolism)
- prevention of DVT and pulmonary embolism

Other advantages were case management (continuity of care) by qualified personnel, routine risk assessment, and regular scheduling of INR tests, all consistent with the consensus guidelines of the Anticoagulation Guidelines Task Force.[3] These activities were associated with fewer warfarin orders per patient, more clinical pharmacy time (i.e., total of 16 to 139 minutes for 1 to 10 patients per day) and only 1 minor bleeding event (hematoma).

It has been subjectively reported that the delegation of warfarin management to pharmacy is beneficial because it reduces nursing and physician time.[4,15,18,20] Other sites (such as Burnaby Hospital in Burnaby, British Columbia) have seen other benefits[4,15,18,20]:

- less time and fewer telephone calls between nurses and physicians for ordering INR tests and for transmitting daily warfarin orders
- less time spent contacting the laboratory for INR results and orders (and faster response time by pharmacists)
- more efficient management of warfarin drug interactions (i.e., changing to noninteracting substitutes)
- greater credibility for pharmacists among other hospital staff and hospital administration through requirement for training and certification in warfarin management[3,24,33]
- routine quality control to support safe and effective anticoagulation management
- greater patient mobility (through earlier discontinuation of unfractionated heparin and LMWH)
- earlier hospital discharge (i.e., faster time to therapeutic INR)

### Feasibility and Sustainability of Warfarin Dosing Service

This evaluation clearly showed that a warfarin dosing service at Providence Healthcare would be safe, effective, efficient, and feasible. The use of standardized warfarin nomograms and protocols and the availability of qualified personnel led to favourable results. The higher rate of morbidity and mortality in the 2 control groups strongly supports implementation of a hospital-wide warfarin dosing service.

Sustainability of the hospital-wide warfarin dosing service will depend upon the volume of patients, clinical pharmacy resources, physician referrals, and other factors. There was strong demand to expand the service throughout the hospital. If this expansion takes place, the anticoagulation pharmacists could set the following 12-month goals:

- maximum of 40 min for work-up for a new patient (by using a simplified patient monitoring form)
- maximum of 20 min for initial interview for a new patient
- maximum of 20 min daily for each patient requiring follow-up (obtaining INR results, writing warfarin orders, risk assessment, etc.)

Through its 2004/2005 business plan, Pharmacy Services at Providence Healthcare was successful in obtaining an additional 0.6 full-time equivalent dispensary pharmacist to allow clinical pharmacists more time for the warfarin dosing service. More resources may be required in the future as the service grows, such as funding for new certified anticoagulation pharmacists, continuing education, and semiannual audits. However, reallocation of resources to the warfarin dosing service may decrease morbidity, mortality, nursing time, and physician time.

## CONCLUSIONS

This evaluation of the pilot project clearly showed that the pilot warfarin dosing service at Providence Healthcare was safe, effective, efficient, and feasible. The availability of qualified personnel is necessary to ensure optimal anticoagulation and safe, continuous patient care and to minimize risk and liability.[3,24,33]

The following benefits of delegating warfarin management to qualified personnel (such as anticoagulation pharmacists) may be realized:

- a decrease in nursing and physician time
- less time and fewer telephone calls between nurses and physicians for tracking and ordering INR tests and for adjusting daily warfarin orders
- less time spent contacting the laboratory for INR results and INR orders
- more efficient management of warfarin drug interactions (i.e., assessment of major warfarin interactions that may or may not require drug substitutions)
- greater credibility for pharmacists among other hospital staff and hospital administration through the requirement that all pharmacists be trained and certified in warfarin management
- routine quality control to support safe and effective anticoagulation management
- greater patient mobility through earlier discontinuation of unfractionated heparin and LMWH
- earlier hospital discharge (i.e., faster time to therapeutic INR)
- more comprehensive patient counselling

The results reported here support the implementation of a hospital-wide warfarin dosing service. Allocation of resources to this service will decrease morbidity, mortality, nursing time, and physician time at Providence Healthcare.

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