Comparison of a Frail-Friendly Nomogram with Physician-Adjusted Warfarin Dosage for Prophylaxis after Orthopaedic Surgery on a Geriatric Rehabilitation Unit

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RÉSUMÉ

Le dosage de la warfarine pour la thromboprophylaxie chez les patients qui viennent d'être opérés prend beaucoup de temps.

Des nomogrammes permettant de doser la warfarine peuvent être utilisés pour les patients qui ont été subi une arthroplastie, mais les besoins en matière de warfarine sont moins élevés chez les personnes âgées frêles. Nous avons modifié un nomogramme existant utilisé pour la post-arthroplastie pour l'adapter aux personnes frêles, et nous avons évalué sa performance après des opérations orthopédiques sur des personnes âgées frêles dans une unité de réadaptation gériatrique, afin de déterminer si cela améliorerait la qualité des indicateurs pour l'anticoagulothérapie orale. Dans une unité de réadaptation gériatrique, nous avons attribué aux patients ayant subi une opération orthopédique soit un dosage de warfarine ajusté par le médecin, soit un nomogramme administré par les infirmières. La proportion de jours passés dans le cadre des valeurs du RIN était sensiblement plus élevé dans le groupe avec nomogramme (77 %, 95 % IC 74 %-81 %) que dans le groupe où le médecin effectuait les ajustements (53 %, 95 % IC 46 %-60 %) sans qu'il n'y ait de complications majeures de type hémorragique ou thromboembolique.

Le nombre d'appels téléphoniques destinés aux médecins au sujet de la warfarine a été divisé par dix.

L'utilisation d'un nomogramme adapté aux personnes frêles a permis d'améliorer la qualité et l'efficacité des soins aux patients dans une unité de réadaptation gériatrique.

ABSTRACT

Warfarin dosing for thromboprophylaxis in post-operative patients is time-consuming. Warfarin-dosing nomograms can be used in post-operative arthroplasty patients, but warfarin requirements are lower in frail older people. We modified an existing post-arthroplasty nomogram to a frail-friendly version and evaluated its performance in a frail elderly post-orthopaedic surgery on a geriatric rehabilitation ward to determine if it would improve quality indicators for oral anticoagulation. On a geriatric rehabilitation unit, post-operative orthopaedic patients were assigned to either physician-adjusted warfarin dosing or the nursing-administered nomogram. The proportion of days within target INR values was significantly higher in the nomogram group (77%, 95% CI 74% to 81%) compared to the physician-adjusted group (53%, 95% CI 46% to 60%), with no major bleeding or thromboembolic complications. The number of warfarin-related telephone calls to physicians was significantly reduced by tenfold. Use of a frail-friendly nomogram improved quality and efficiency of patient care on a geriatric rehabilitation unit.

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Introduction

Deep vein thrombosis and pulmonary embolism are common complications following orthopaedic surgery.[1,2] Current guidelines recommend that thromboprophylactic therapy be continued for a period of at least 10 days,[3,4] and anticoagulation is frequently continued until hospital discharge. Despite the availability of other effective agents, such as low-molecular weight heparin, warfarin remains a frequently used drug for post-orthopaedic surgery thromboprophylaxis in North America. The primary advantage of warfarin in this setting is a lower rate of bleeding during the post-operative period, and when necessary, it can be continued upon discharge, even among frail elderly patients, when appropriate measures are put in place for monitoring.[3] Limitations of warfarin include the need for regular and frequent monitoring and dose adjustments. However, management of anticoagulation can be simplified by the use of warfarin nomograms.

Daily warfarin dosing adjustments by physicians is a fairly time-consuming process for physicians, nurses, and pharmacists. Warfarin dosing nomograms for venous thromboembolic disease have been shown to be safe, effective, and superior to physician-adjusted dosing for both initiation[5–7] and outpatient continuation[7,8] of oral anticoagulation. Pharmacist-directed warfarin dosing programs have been shown to improve quality indicators of oral anticoagulation.[9–12] Computerized management of post-arthroplasty warfarin prophylaxis has been shown to reduce demands on nursing time without compromising patient safety[13] and provides superior INR control.[8] Recently, a warfarin nomogram developed specifically for post-operative hip and knee arthroplasty patients was found to be comparable to haematologist-adjusted warfarin dosing.[14]

However, nomograms must be tailored to the target population. Dosing requirements are lower post-operatively[15,16] and in older patients, especially those with lower body weights.[15] Warfarin dosing requirements decrease with age,[16,17] and commonly used anticoagulant induction and maintenance regimens are associated with over-anticoagulation in older patients.[17–20] This is thought to be related to a number of factors, such as under-nutrition, which results in an underlying vitamin-K deficiency, and a relative inability of the liver to produce clotting factors,[17] decreased warfarin clearance, or the use of concomitant drugs that may enhance the anticoagulant activity of warfarin.[18,19] Nonetheless, it may be possible to predict safe and effective warfarin dosing in older patients.[21]

We modified a published post-arthroplasty warfarin dosing nomogram[14] specifically for the thromboprophylaxis of frail elderly orthopaedic patients in a geriatric rehabilitation unit, all of whom had already received induction doses. The purpose of this study was to compare the quality of warfarin management using the frail-friendly nomogram with that of physician-adjusted dosing (usual care) in hip fracture and elective hip arthroplasty patients who required a stay in geriatric rehabilitation prior to returning home. We compared the mean proportion of time within the target international normalized ratio (INR) range and the number of INR-driven phone calls made by nursing staff to physicians.

Methods

Post-operative hip fracture or elective hip arthroplasty patients at the Queen Elizabeth II Health Sciences Centre are anticoagulated with warfarin at the orthopaedic surgeon's discretion. Frail elderly patients who require a period of rehabilitation prior to returning home are transferred to the Geriatric Restorative Care Unit (GRCU) and anticoagulation is routinely continued until discharge home. Warfarin anticoagulation is initiated on the orthopaedic service, using the nomogram developed by Anderson et al.[14] On transfer to GRCU, the Anderson nomogram is discontinued and usual care is daily, physician-adjusted warfarin dosing. On admission to the GRCU, patients are assigned to one of two teams. Which team receives the new admissions depends solely on the number of patients managed by each team at that time. Each team is staffed with three family physicians who manage warfarin dosing for their individual patients. To compare the nomogram to physician-adjusted dosing, we arbitrarily assigned one team to continue with usual care and the other team to use a modified frail-friendly version of the Anderson nomogram.

The Anderson nomogram uses daily INR determinations and aims to maintain INR between 1.8 and 2.5.[5,14] This range was chosen to optimize prophylaxis while reducing the risk of bleeding.[22] Prophylaxis

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INR	<1.4	<1.5	<1.6	<1.7	<1.8	<1.9	<2.0	<2.1	<2.2	<2.3	<2.4	<2.5	<2.6	<2.7	<2.8	<2.9	<3.0
Dose[a]	5	4	4	4	3	2.5	2.5	2	2	2	1	1	1	0.5	0.5	0.5	1

a All doses in mg. This nomogram is used in conjunction with daily International Normalized Ratio (INR) testing. The physician is called anytime the INR is >3.5 or the INR <1.8 on more than two consecutive days or if the nomogram gives a warfarin dose which deviates from yesterday's dose by more than 2 mg. The target INR range is between 1.8 and 2.5 until hospital discharge.

Figure 1: Modified Anderson warfarin nomogram for geriatric rehabilitation patients after orthopaedic surgery

within this INR range is both safe and effective for the prevention of venous thromboembolic complications following orthopaedic surgery[23] and we chose to adopt this range. The Anderson nomogram is part of the standing orders on orthopaedic patients and has a different dosing protocol, depending upon INR, on days 0 through 8; it then remains the same on subsequent days. The Anderson nomogram was modified to the frail-friendly version through a consensus process, including staff geriatricians and a clinical pharmacist with expertise in anticoagulation. We started with the final day of the Anderson nomogram and adjusted it specifically to reduce the risk of overanticoagulation in the frail elderly, to ensure that patients who were particularly sensitive to warfarin were identified and brought to the attention of the physician early, and to minimize fluctuations in the degree of anticoagulation. The frail-friendly nomogram is shown in Figure 1.

Patients with known contra-indications to warfarin or with any additional reason for anticoagulation other than post-operative thromboprophylaxis were excluded. Thromboembolic and bleeding episodes were recorded. Descriptive statistics and Student's *t* test were used to compare the performance of the frail-friendly nomogram with physician-adjusted dosing and the number of INR-related phone calls by nursing.

Results

One-hundred-and-thirty-six patients were included (71% female), with an average age of 81 years (range 62–95 years). The mean number of days spent on the orthopaedic unit prior to transfer to the GRCU was 18 days ($SD = 11$) and the average length of stay on the GRCU was 24 days. There was no statistical difference between groups in terms of gender distribution, age, days on warfarin prior to transfer, or length of stay.

There was an average of 0.04 deviations from the nomogram per day in the nomogram group. Six patients were switched from the nomogram to physician-adjusted dosing. In two cases, another indication for anticoagulation was diagnosed, rendering the patient ineligible for the nomogram. In two cases, the length of stay was more than 40 days,

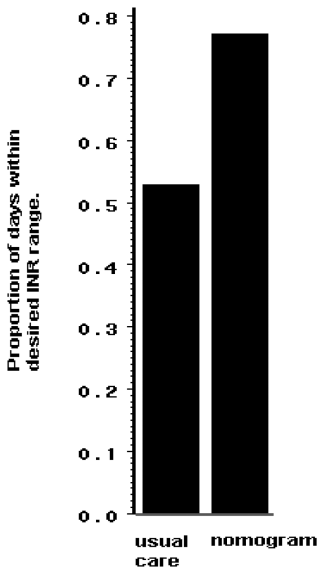

Figure 2: Proportion of days spent within the desired INR range (1.8–2.5) for the physician-adjusted group versus the frail-friendly nomogram group ($p < 0.0001$)

prompting the physician to remove the patient from the nomogram to avoid daily blood draws to determine INR. In one case, the patient was switched to physician-adjusted dosing due to persistently low INR values while on the nomogram. In the final case, the reasons for switching were unclear.

As shown in Figure 2, the proportion of days within the INR target range of 1.8 to 2.5 was significantly higher at 77 per cent in the nomogram group (95% CI 74% to 81%) than at 53 per cent (95% CI 46% to 60%) in the physician-adjusted group ($p < 0.0001$). The proportion of days with an INR greater than 3.5 was 0.9 per cent (95% CI, 0.3% to 1.5%) in the nomogram group and 3.4 per cent (95% CI, 1.2% to 5.6%) in the physician-adjusted group ($p < 0.0004$). Two patients had INR values greater than 4.5, one in each group. Of note, in the nomogram group, the physician had deviated from the nomogram the preceding four consecutive days.

The number of phone calls to physicians by nursing staff directly related to warfarin dosing was dramatically reduced, with an average of 0.7 (95% CI, 0.60 to 0.71) phone calls per day in the physician-adjusted

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group, compared to 0.07 (95% CI, 0.04 to 0.09) calls per day ($p < 0.001$) in the nomogram group.

There was one minor bleeding episode (epistaxis) in the nomogram group, which did not require medical therapy and occurred within the target INR range. One patient in the physician-adjusted group developed a DVT, which was associated with a sub-therapeutic INR value.

Discussion and Conclusions

This warfarin dosing nomogram, adapted specifically for the frail, older, rehabilitation patient from an accepted post-orthopaedic surgery nomogram, was used successfully on our unit. Patient care was not compromised; indeed, the nomogram performed significantly better than the physician-adjusted method. Nomograms for the initiation of warfarin have been described and have been shown to be superior to standard care.[5] This nomogram was designed specifically for the continuation of anti-coagulation in patients who had already received loading doses. This may explain why the percentage of days with INR's in the target range (77%) was higher than previously reported for the Anderson nomogram (61%).[14] A mean percentage of time with INR of between 1.8 to 2.5 in the physician-adjusted group was similar to previously reported rates.[8,14] It should be noted that the frail-friendly nomogram is not intended to find a stable daily dose, as warfarin is discontinued prior to discharge.

The target INR range used in this study was 1.8 to 2.5, in agreement with the Anderson nomogram. This range was selected to minimize the risk of post-operative bleeding in orthopaedic patients throughout the duration of their stays on the surgical service.[14] Our frail-friendly nomogram was designed to reduce the risk of over-anticoagulation among the frail elderly rehabilitation patient population, in accordance with decreased warfarin dosage requirements in this group. While we recognize that the sample size is insufficient to compare thromboembolic and bleeding events, among those patients using the nomogram there were no major bleeding or thromboembolic episodes.

While pharmacist-directed warfarin dosing programs have also been demonstrated to improve quality indicators of oral anticoagulation with warfarin,[9–11] current pharmacist resources do not permit this service to be provided on all medical/surgical units. One advantage of a nomogram is that it can be administered by nursing staff. This allows it to be incorporated into routine admission orders for appropriate orthopaedic patients transferred to the GRCU for rehabilitation. Furthermore, with physician-adjusted dosing, on-call physicians, who do not know the patient's age, circumstances, or previous INR response to warfarin, may be required to adjust the warfarin dose. Of note, the time spent by nurses contacting physicians by phone to address issues related to sub- or supra-therapeutic values and warfarin dosing was significantly reduced, by a factor of 10, in the modified nomogram group. Given the pressures of patient care associated with the frail elderly, the observed decrease in warfarin-related phone calls was likely quite meaningful in terms of nursing time.

Limitations of this study include the requirement for daily INR measurements. This was done to ensure that patients who were very sensitive to warfarin would be identified early. However, it is conceivable that our nomogram could be further modified to accommodate less frequent INR monitoring.

The need for post-operative thromboprophylaxis with warfarin following orthopaedic surgery in frail older adults requiring rehabilitation is common. The main advantages of our frail-friendly warfarin nomogram in this population include the greater amount of time spent in the target INR range and the significant decrease in the number of warfarin-related phone calls to physicians by nursing. The results of this study may be generalizable to the relatively homogenous, post-operative orthopaedic geriatric rehabilitation population.

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