



[haematologica]
2004;89:586-593

Thromboprophylaxis practice patterns in two Western Australian teaching hospitals

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A B S T R A C T

Background and Objectives. Evidence-based international guidelines recommend that all patients undergoing elective hip or knee arthroplasty receive thromboprophylaxis with low-molecular-weight heparin or adjusted-dose warfarin. Our objective was to determine what proportion of patients undergoing elective hip or knee arthroplasty actually receive recommended thromboprophylaxis according to international guidelines.

Design and Methods. We performed a prospective cohort study of 396 consecutive patients undergoing elective hip or knee arthroplasty between 1 May and 30 October, 2002. We collected baseline data, surgical and anesthetic details and recorded use of thromboprophylaxis and episodes of venous thromboembolism that occurred within 3 months of surgery.

Results. The mean age of the patients was 69.4 years (SD 11.5 years), and 62.2% (95% CI: 57.3 to 66.9%) were female. Hip arthroplasty was performed in 39.4% (34.6 to 44.2%) and knee arthroplasty in 57.1% (52.2 to 61.9%). Recommended thromboprophylaxis with low-molecular-weight heparin or warfarin was administered to 51.5% (46.6 to 56.4%). Objectively diagnosed venous thromboembolism occurred in 5.3% (3.3 to 8.0%) of patients; 3.5% (1.9 to 5.9%) of events occurred during hospitalization and 1.8% (0.7 to 3.6%) occurred following discharge from hospital. There was no significant reduction in the incidence of venous thromboembolism among patients treated with recommended thromboprophylaxis compared with those who did not but this is not a randomized comparison and is potentially confounded by the indication for treatment.

Interpretation and Conclusions. Current thromboprophylaxis practice at our institutions falls substantially short of national and international guidelines. The reasons for low thromboprophylaxis use should be further explored and strategies for change implemented in order to optimize clinical practice.

Key words: venous thromboembolism, surgery, thromboprophylaxis, guidelines.

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Venous thromboembolism occurs in one to two individuals per 1000 persons in the general community^{1,2} and remains one of the single most common causes of preventable death among hospitalized patient.^{3,4} Patients undergoing elective hip or knee arthroplasty are at very high risk of venous thromboembolism; asymptomatic deep vein thrombosis occurs in 40–60% and symptomatic venous thromboembolism, including fatal pulmonary embolism, occurs in up to 5% of these patients.⁵ Furthermore, with the aging of the Australian population and associated increasing utilization of hip and knee arthroplasty for the treatment of degenerative joint diseases, the morbidity, mortality, and health care costs of venous thromboembolism in this high-risk population are likely to rise.^{6–9} Since 1988 it has been known, from a systematic review of randomized controlled trials, that thrombo-

prophylaxis with low-molecular-weight heparin or warfarin reduces the risk of venous thromboembolism, including non-fatal symptomatic events and fatal pulmonary embolism, by about 50% among high-risk orthopedic patients.¹⁰ However, surveys conducted during the 1990s suggested that only one-quarter to one-half of Australian and New Zealand surgeons routinely prescribed pharmacological thromboprophylaxis in high-risk orthopedic patients.^{11–13} Moreover, a recent single-center audit in Canberra published in 2002 demonstrated that only 5% of high-risk hospitalized patients received appropriate thromboprophylaxis,¹⁴ which is considerably lower than the percentage reported in contemporary North American studies.^{15–18} Appropriate thromboprophylaxis therefore varies widely, but wherever, it is underutilized.⁵ The American College of Chest Physicians therefore

published guidelines in 2001 to augment the uptake of level 1 evidence into clinical practice. They recommended that all patients undergoing hip or knee arthroplasty receive prophylaxis with either low-molecular-weight heparin or adjusted-dose warfarin for at least 7–10 days (Grade 1A recommendation).⁵ Similar recommendations were made concurrently by Australian and other International experts.¹⁹

In order to determine the uptake of the evidence-based guidelines for perioperative thromboprophylaxis, and its possible impact on the incidence of symptomatic venous thromboembolism, bleeding and death during the three months after these operations, we conducted a prospective cohort study of the frequency, type and duration of recommended thromboprophylaxis for elective hip or knee arthroplasty at two major West Australian teaching hospitals in 2002.

Design and Methods

This study was conducted in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki declaration of 1975, as revised in 2000.²⁰

Patients

All patients admitted to Royal Perth Hospital and Sir Charles Gairdner Hospital, Western Australia, for elective hip or knee arthroplasty from 1 May to 30 October 2002 were included. Eligible patients were identified by a dedicated study nurse using daily admissions lists.

Data sources

Data were obtained by the study nurse from the clinical history, the patients' charts, surgical records, anaesthetic records, radiology and pathology reports, and medication charts. Verification of outpatient events was obtained from the General Practitioner or radiology practice in those cases in which the results of objective diagnostic testing were not readily available.

Data collection commenced at the time of admission to hospital or as soon as possible thereafter (usually within 48 hours) and the patients were followed throughout their admission to identify any changes in management or clinical outcomes. All patients were followed-up at three months by telephone interview to determine whether any clinical outcomes had occurred since discharge from hospital.

Data collection

We obtained the following baseline data for each patient: demographic data (age, gender); clinical factors for venous thromboembolism (previous history of venous thromboembolism, active malignancy); reg-

ular medications on admission that may affect the risk of venous thromboembolism or bleeding (aspirin, clopidogrel, non-steroidal anti-inflammatory drugs, warfarin, oral contraceptive pill, hormone replacement therapy). In-hospital data included: the date and type of surgery (hip arthroplasty, knee arthroplasty, bilateral or combined procedure); type of anesthetic (general, spinal, epidural, combined general and spinal and/or epidural); the type and duration of post-operative thromboprophylaxis, including mechanical (graduated compression stockings, intermittent pneumatic compression devices) or pharmacological measures (low-molecular-weight heparin, warfarin, low-dose or adjusted-dose unfractionated heparin, antiplatelet therapies [aspirin, clopidogrel]); and clinical outcomes during hospitalization or within three months of surgery (objectively diagnosed symptomatic venous thromboembolism, major bleeding, deaths). For the purpose of this study, patients were considered to have received recommended thromboprophylaxis if they were treated with low-molecular-weight heparin or warfarin irrespective of the duration of treatment.

Clinical outcomes

Venous thromboembolism was recorded as a clinical outcome only if the patient's symptoms led the clinician to suspect the diagnosis and venous thromboembolism and was then confirmed to be present by objective diagnostic testing. For deep vein thrombosis this required compression ultrasound or ascending contrast venography and for pulmonary embolism this required ventilation perfusion lung scanning or spiral computed tomography of the chest. We accepted the diagnosis as reported and did not attempt to re-adjudicate any outcome events.

The outcome of bleeding or transfusion included bleeding requiring surgical intervention, a reduction in hemoglobin of at least 20 g/L or transfusion with packed red cells. Patients with multiple episodes of venous thromboembolism or with multiple episodes of bleeding or transfusion were counted only once.

Analyses

Continuous data are presented as means and standard deviations when normally distributed and were compared using a t-test. Skewed data (not normally distributed) are presented as medians and range and were compared using non-parametric statistics (Wilcoxon rank sum test). Categorical data are presented as numbers and proportions and were compared using a χ^2 test or Fisher's exact test.

Logistic regression models were used to examine the association between recommended thromboprophylaxis with low-molecular-weight heparin or warfarin and venous thromboembolism or bleeding after adjustment

Table 1. Baseline patients' characteristics and operative details.

Characteristic	Hip replacement*		Knee replacement*		Total	
	Number, n (N=157)	% (95% CI)	Number, n (N=220)	% (95% CI)	Number, n (N=396)	% (95% CI)
Age in years, mean (SD)	67.6 (13.4)	–	71.1 (9.8)	–	69.4 (11.5)	–
Males	67	42.7% (34.9 to 50.4%)	75	34.1% (27.8 to 40.3%)	150	37.8% (33.1 to 42.7%)
Weight, mean (SD)	79.2 (16.6)	–	83.1 (15.0)	–	81.4 (15.7)	–
Current Smoker	20	12.7% (7.5 to 18.0%)	31	14.2% (9.6 to 18.9%)	57	14.4% (10.9 to 17.9%)
Prior venous thromboembolism					36	9.1% (6.4 to 12.4%)
Malignancy	11	7.1% (3.0 to 11.1%)	20	9.1% (5.3 to 12.9%)	32	8.1% (5.6 to 11.2%)
Regular medications						
aspirin	37	23.9% (17.2 to 30.6%)	65	29.5% (23.5 to 35.6%)	106	26.8% (22.4 to 31.1%)
warfarin	10	6.4% (2.4 to 10.2%)	18	8.2% (4.6 to 11.8%)	28	7.1% (4.7 to 10.1%)
hormone replacement	13	8.3% (4.0 to 12.6%)	21	9.5% (5.7 to 13.4%)	37	9.3% (6.7 to 12.6%)
Anesthetic						
General alone	37	23.6% (16.9 to 30.2%)	23	10.4% (6.4 to 14.5%)	63	15.9% (12.3 to 19.5%)
Regional alone	11	7.0% (3.0 to 11.0%)	2	0.9% (0 to 3.3%)	14	3.5% (1.9 to 5.9%)
Combined general and regional	109	69.4% (62.2 to 76.6%)	195	88.6% (84.4 to 92.8%)	319	80.6% (76.7 to 84.5%)
Minutes in OR, mean (SD)	134.7 (45.7)	–	117.8 (34.2)	–	124.0 (39.9)	–

*19 patients underwent hemi-arthroplasty or a bilateral procedure. SD denotes standard deviation.

for baseline differences between patients who did or did not receive recommended thromboprophylaxis.

Results

We included 396 consecutive patients admitted to Royal Perth Hospital (n=228) or Sir Charles Gairdner Hospital (n=168) for elective hip or knee arthroplasty between 1 May to 30 October 2002.

Baseline characteristics

The patients' baseline characteristics are summarized in Table 1. Their mean age was 69.4 years (SD 11.5) and 62.1% were female. More than one quarter (26.9%, 95% CI: 22.4 to 31.1%) were taking aspirin for other indications at the time of hospital admission. Thirty-six patients (9.1%, 95% CI: 6.4 to 12.4%) had a history of venous thromboembolism and 32 patients (8.1%, 95% CI: 5.6 to 11.2%) had known malignancy at the time of hospital admission.

Operative details

The operative details of patients undergoing hip or knee arthroplasty who were included in our study are

summarized in Table 1. Hip arthroplasty was undertaken in 39.4% (95% CI: 34.6 to 44.2%) of patients, and knee arthroplasty in 51.7% (95% CI: 52.2 to 61.9%). The majority of patients (80.6%, 95% CI: 76.7 to 84.5%) received combined general and regional anesthesia.

Thromboprophylaxis

At least one form of mechanical, pharmacological, or combined mechanical and pharmacological thromboprophylaxis was administered to 95.7% (95% CI: 93.2 to 97.5%) of patients undergoing hip or knee arthroplasty. However, only 51.5% (95% CI: 41.6 to 56.4%) received recommended thromboprophylaxis with low-molecular-weight heparin or warfarin, including 40.7% (35.8 to 45.5%) who received low-molecular-weight heparin and 15.2% (11.6 to 18.7%) who received warfarin. In all cases, low-molecular-weight heparin or warfarin thromboprophylaxis was commenced post-operatively. Most of the remainder received mechanical thromboprophylaxis with stockings, foot pumps, or aspirin (Table 2).

At least one form of thromboprophylaxis was continued beyond hospital discharge in 56.6% (95% CI: 49.5 to 64.1%) of patients but, after exclusion of those taking aspirin or warfarin at the time of hospital admission,

Table 2. Post-operative thromboprophylaxis use in patients undergoing hip or knee arthroplasty.

Thromboprophylaxis	Hip replacement*		Knee replacement*		Total	
	Number, n (N=157)	% (95% CI)	Number, n (N=226)	% (95% CI)	Number, n (N=396)	% (95% CI)
Mechanical						
TED stockings	107	68.2% (60.9 to 75.4%)	106	48.2% (41.6 to 54.8%)	222	56.1% (51.2 to 60.9%)
Foot pump	70	44.6% (36.8 to 52.4%)	65	29.5% (23.5 to 35.6%)	138	34.8% (30.2 to 39.5%)
Any mechanical	109	69.4% (62.2 to 76.6%)	109	49.5% (42.9 to 56.2%)	227	57.3% (52.5 to 62.2%)
Pharmacological						
LMWH	81	51.6% (43.8 to 59.4%)	76	34.5% (28.3 to 40.8%)	161	40.7% (35.8 to 45.5%)
UFH	13	8.3% (3.4 to 12.6%)	11	5.0% (2.1 to 7.9%)	24	6.1% (3.9 to 8.9%)
Warfarin	16	10.2% (5.5 to 14.9%)	43	19.5% (14.3 to 24.8%)	60	15.2% (11.6 to 18.7%)
Aspirin	66	42.0% (34.3 to 49.8%)	112	50.9% (44.3 to 57.5%)	187	47.2% (42.3 to 52.1%)
LMWH or warfarin	91	58.0% (50.2 to 65.7%)	108	49.1% (42.5 to 55.7%)	204	51.5% (46.6 to 56.4%)
Aspirin alone	37	23.6% (16.9 to 30.2%)	78	35.4% (29.1 to 41.8%)	123	31.1% (26.5 to 35.6%)
Continued out-of-hospital ^o	70	44.6% (36.8 to 52.4%)	150	68.2% (62.0 to 74.3%)	224	56.6% (49.5 to 64.1%)
LMWH ^o	3	2.7% (0 to 7.7%)	12	8.6% (3.4 to 13.3%)	15	5.7% (3.2 to 9.2%)
Warfarin ^o	7	6.3% (1.8 to 10.8%)	30	21.6% (14.7 to 28.4%)	38	14.3% (10.1 to 18.6%)
LMWH or warfarin ^o	10	9.0% (3.7 to 14.3%)	39	28.1% (20.6 to 35.5%)	50	18.9% (14.2 to 23.6%)
Aspirin alone ^o	21	18.9% (11.6 to 26.2%)	32	23.0% (16.0 to 30.0)	53	20.0% (15.2 to 24.8%)

*19 patients underwent hemi-arthroplasty or a bilateral procedure. ^oThe denominator here is the patients who were not taking aspirin or warfarin at the time of admission to hospital. LMWH denotes low-molecular-weight heparin; UFH, unfractionated heparin.

recommended thromboprophylaxis with low-molecular-weight heparin, warfarin or both was continued out-of-hospital in 50/265 (18.9%) patients. After excluding those patients taking pharmacological thromboprophylaxis prior to admission to hospital the median duration of thromboprophylaxis was 8 days.

Clinical outcomes

Twenty-one patients (5.3%, 95% CI: 3.3 to 8.0%) developed objectively diagnosed venous thromboembolism within three months of surgery, five in patients who had undergone hip replacement surgery and 16 in patients who had undergone knee replacement. Approximately two-thirds of these events occurred during hospitalization (3.5%, 95% CI: 1.9 to 5.9%) and one-third after discharge from hospital (1.8%, 95% CI: 0.7 to 3.6%) (Table 3). Fifteen events (3.8%, 95% CI: 2.1 to 6.2%) presented as deep vein thrombosis, approximately one-half of which occurred in hospital and one-

half after discharge. All six episodes of pulmonary embolism occurred during hospitalization.

Three patients died, one in hospital of a myocardial infarction and two following discharge from hospital: one of these deaths was caused by *Escherichia Coli* meningitis, the other by suicide. Bleeding occurred or transfusion was required in 150/396 (37.9%) patients during hospitalization (Table 3).

Clinical outcomes according to thromboprophylaxis with low-molecular-weight heparin or warfarin

A similar proportion of patients who received low-molecular-weight heparin or warfarin developed venous thromboembolism compared with those who did not receive recommended thromboprophylaxis (5.4% versus 5.2%), and the proportions were also similar among those treated with low-molecular weight heparin (5.6%; 2.6 to 10.3%) compared with warfarin (3.3%; 0.4

Table 3. Clinical Outcomes within three months of elective hip or knee arthroplasty.*

Outcome	Hip replacement*		Knee replacement*		Total	
	Number, n (N=157)	% (95% CI)	Number, n (N=226)	% (95% CI)	Number, n (N=396)	% (95% CI)
Symptomatic VTE						
Total	5	3.2% (1.0 to 7.3%)	16	7.3% (4.2 to 11.6%)	21	5.3% (3.3 to 8.0%)
In hospital	3	1.9% (0 to 5.5%)	11	5.0% (2.5 to 8.8%)	14	3.5% (1.9 to 5.9%)
Out of hospital	2	1.3% (0 to 4.6%)	5	2.3% (0 to 5.3%)	7	1.8% (0.7 to 3.6%)
Deep vein thrombosis						
Total	4	2.5% (0 to 6.4%)	11	5.0% (2.5 to 8.8%)	15	3.8% (2.1 to 6.2%)
In hospital	2	1.3% (0 to 4.6%)	6	2.7% (1.0 to 5.9%)	8	2.0% (0.9 to 3.9%)
Out of hospital	2	1.3% (0 to 4.6%)	5	2.3% (0 to 5.3%)	7	1.8% (0.7 to 3.6%)
Pulmonary embolism						
Total	1	0.6% (0 to 3.5%)	5	2.3% (0 to 5.3%)	6	1.5% (0.6 to 3.3%)
In hospital	1	0.6% (0 to 3.5%)	5	2.3% (0 to 5.3%)	6	1.5% (0.6 to 3.3%)
Out of hospital	0	—	0	—	0	—
Bleeding or transfusion	79	50.3% (42.5 to 58.1%)	69	31.4% (25.2 to 37.5%)	150	37.9% (33.1 to 42.7%)
Death	0	—	3	1.4% (0 to 4.0%)	3	0.8% (0.2 to 2.2%)

*Three patients were lost to follow-up at three months; VTE denotes venous thromboembolism.

Table 4. Clinical outcomes within three months of elective hip or knee arthroplasty according to type of thromboprophylaxis.*

Outcome	Low-molecular weight heparin % (95% CI)	Warfarin % (95% CI)	Low-molecular-weight heparin or warfarin % (95% CI)	Neither % (95% CI)
Symptomatic VTE				
Total	5.6% (2.5 to 10.4%)	3.3% (0 to 11.6%)	5.4% (2.7 to 9.5%)	5.2% (2.5 to 9.4%)
In hospital	3.1% (1.0 to 7.1%)	3.3% (0 to 11.6%)	3.4% (1.3 to 11.6%)	3.6% (1.4 to 7.4%)
Out of hospital	2.5% (0 to 6.3%)	0	2.0% (0 to 5.0%)	1.6% (0 to 5.4%)
Deep vein thrombosis				
Total	5.0% (2.1 to 9.6%)	1.7% (0 to 9.0%)	4.4 (2.0 to 8.3%)	3.1 (1.1 to 6.7%)
In hospital	2.5% (0 to 6.3%)	1.7% (0 to 9.0%)	2.5 (0 to 5.7%)	1.6 (0 to 4.5%)
Out of hospital	2.5% (0 to 6.3%)	0	2.0 (0 to 5.0%)	1.6 (0 to 4.5%)
Pulmonary embolism				
Total	0.6 (0 to 3.5%)	1.7% (0 to 9.0%)	1.0 (0 to 3.5%)	2.1 (0 to 5.3%)
In hospital	0.6 (0 to 3.5%)	1.7% (0 to 9.0%)	1.0 (0 to 3.5%)	2.1 (0 to 5.3%)
Out of hospital	0	0	0	0
Bleeding or transfusion	47.2% (39.4 to 54.9%)	36.7% (24.5 to 50.2%)	44.6% (37.8 to 51.4%) ^o	30.7% (24.2 to 37.2%) ^o
Death	1.2% (0 to 4.5%)	0	1.0% (0 to 3.5%)	0.5% (0 to 2.9%)

*Three patients were lost to follow-up at three months; ^op<0.05 for comparison between low molecular weight heparin or warfarin versus neither; VTE denotes venous thromboembolism.

to 11.5%) (Table 4). By contrast, a significantly greater proportion of patients who received low-molecular-weight heparin or warfarin developed bleeding or required transfusion (44.6% versus 30.7%, p=0.004).

However, these comparisons are potentially confounded because this was not a randomized study and

patients at highest risk of bleeding complications were also likely to have been at the highest risk of venous thromboembolism and thus most likely to have received thromboprophylaxis with low-molecular-weight heparin or warfarin.

Logistic regression modeling revealed that after

adjustment for age, gender, body weight, prior history of venous thromboembolism, known malignancy, drugs, type of surgery (hip versus knee), time spent in the operating room, duration and type of anesthetic (regional versus general vs. combined regional and general), there was no association between recommended thromboprophylaxis and risk of venous thromboembolism (OR 1.0; 95% CI: 0.4 to 2.5, $p=1.0$) but treatment with low-molecular-weight heparin or warfarin therapy was independently predictive of bleeding or need for transfusion (OR 1.74; 95% CI 1.1 to 2.7, $p=0.004$). A similar analysis to examine an independent association between low-molecular-weight heparin or warfarin thromboprophylaxis and venous thromboembolism risk was not possible because of the small number of outcome events. Likewise an association between duration of thromboprophylaxis or duration of hospitalization and risk of venous thromboembolism could not be demonstrated.

Discussion

Our study demonstrates that at least one form of pharmacological or mechanical thromboprophylaxis was administered to more than 90% of patients undergoing hip or knee arthroplasty in two Western Australian teaching hospitals but that the recommended guidelines were followed in only about one-half of patients. Recommended treatment was continued beyond hospital discharge in less than one quarter of patients. These efforts failed to prevent symptomatic venous thromboembolism in 5.3% of patients (95% CI: 3.3 to 8.0%); two-thirds of these events occurred in hospital and one-third after discharge from hospital.

The high rate of thromboprophylaxis use suggests that there is widespread awareness of hip and knee arthroplasty as a risk factor for venous thromboembolism among orthopedic surgeons in the hospitals surveyed in our study. However, our data indicate that the most effective type of thromboprophylactic regimen, as recommended by international guidelines, is not being implemented. Our data also appear to suggest that the type of thromboprophylaxis did not influence patient outcome (i.e. the incidence of venous thromboembolism was similar among patients treated with low-molecular-weight heparin, warfarin, or those who did not receive recommended thromboprophylaxis with one of these agents), but this comparison is potentially flawed because the non-randomized design of this study did not allow for systematic bias in treatment allocation to be minimized (patients were not randomized to different thromboprophylactic regimens and, indeed, it is likely that those at highest risk of venous thromboembolism were also selected to receive more

intensive thromboprophylaxis), and the small number of outcome events failed to minimize the play of random chance (the 95% confidence intervals of the odds ratio are wide and are consistent with a 2.5-fold odds reduction or odds increase in venous thromboembolism associated with recommended thromboprophylaxis). Nevertheless, the 5% incidence of symptomatic venous thromboembolism in patients who received recommended thromboprophylaxis is higher than expected and suggests that prophylaxis failure is a common and important cause of venous thromboembolism in high risk orthopedic patients.²¹

One of the impediments to more widespread use of thromboprophylaxis in patients undergoing major orthopedic surgery is concern regarding the risk of bleeding. Bleeding complications are highly visible and frequently attributed to the use of thromboprophylaxis. Randomized studies have demonstrated only a marginal increase in the risk of major hemorrhage associated with low-molecular-weight heparin or warfarin thromboprophylaxis.⁵ Approximately one in three patients in our study experienced bleeding or required transfusion and treatment with low-molecular-weight heparin or warfarin appeared to be independently associated with the risk of bleeding or transfusion. We did not collect data on different subtypes of bleeding but a substantial proportion of these events is likely to have been attributable to factors other than the use of thromboprophylaxis (e.g. the nature of the surgery being performed). Furthermore, in a non-randomized study, the relation between thromboprophylaxis and bleeding or transfusion may be confounded because those patients who are at highest risk of bleeding may also be those at greatest risk of venous thromboembolism and therefore most likely to receive thromboprophylaxis. Nevertheless, the increase in bleeding or transfusion associated with low-molecular-weight heparin or warfarin suggests that safer thromboprophylaxis strategies are required in patients undergoing elective hip or knee arthroplasty.

A further barrier to the more widespread use of thromboprophylaxis in high-risk orthopedic patients is the belief that advances in surgical and medical management have reduced the incidence of venous thromboembolism to an insignificant level.⁵ Venous thromboembolism is frequently a silent disease in patients undergoing major orthopedic surgery, which reduces the perceived efficacy of thromboprophylaxis, while failures of thromboprophylaxis (patients who develop venous thromboembolism despite thromboprophylaxis) are readily apparent. However, venous thromboembolism remains a common, under-diagnosed and potentially fatal condition, with an incidence in the general community that is comparable to that of stroke¹ and is also a common complication of elective hip or knee

arthroplasty, as highlighted by the results of our study.

The cost of drugs, laboratory monitoring, and the need for clinical follow up may also be considered impediments to the implementation of thromboprophylaxis guidelines in patients undergoing elective hip or knee arthroplasty. However, proper evaluation of the pharmacoeconomics of recommended thromboprophylaxis strategies requires consideration of the incremental cost and incremental effectiveness since it is the cost per event prevented that determines the economic viability of interventions in medicine. Numerous studies have demonstrated that the routine use of low-molecular-weight heparin to prevent venous thromboembolism following hip or knee arthroplasty is highly cost-effective.²²⁻²⁴

By themselves the publication of the results of randomized trials or consensus conference recommendations are insufficient to ensure the routine use of appropriate thromboprophylaxis in high risk hospitalized patients. Improvements in thromboprophylaxis practice patterns have, however, been documented when physicians participate in formal education programs designed to increase awareness of venous thromboembolism, particularly when hospital-specific data are also available to demonstrate the potential benefits of thromboprophylaxis.^{5,25,26} Automated reminder systems for physicians have also been shown to be effective to

improve the use of thromboprophylaxis in high risk populations.²⁷ The development and implementation of such strategies is ultimately an issue of clinical governance that must be addressed at a departmental or institutional level. The American College of Chest Physicians Consensus Conference on Antithrombotic Therapy recommends that every hospital develops a formal strategy addressing the prevention of thromboembolic complications.⁵ Specific reasons why physicians at our institutions did not institute recommended thromboprophylaxis need to be further explored.

In conclusion, our study demonstrates that thromboprophylaxis practice patterns remain suboptimal in patients undergoing surgery for elective hip or knee arthroplasty in our two Western Australian teaching Hospitals. These data should prompt the implementation of strategies to improve thromboprophylaxis practice patterns in this population.

JWE, DJQ, RB, DJW: conception and design of study; JWE, AM, DJW: acquisition of data; JWE, AM, DJW, GJH: analysis and interpretation of data, drafting the article or revising it critically for important intellectual content; JWE, AM, DJQ, RB, DJW, GJH: final approval of the version to be published. The authors reported no potential conflicts of interest.

This study was supported by a grant from Aventis Australia but was designed, conducted, analyzed, and reported independently of the study sponsor.

Manuscript received December 11, 2003. Accepted March 16, 2004.

References

- Anderson FA, Wheeler HB, Goldberg RJ, Hosmer DW, Patwardhan NA, Jovanovic B, et al. A population-based perspective of the hospital incidence and case fatality rates of deep vein thrombosis and pulmonary embolism: the Worcester DVT study. *Arch Intern Med* 1991;151:933-8.
- Silverstein MD, Heit JA, Mohr DN, Pettersen TM, O'Fallon WM, Melton LJ. Trends in the incidence of deep vein thrombosis and pulmonary embolism: a 25-year population-based study. *Arch Intern Med* 1998;158:585-93.
- Sandler DA, Martin JF. Autopsy proven pulmonary embolism in hospital patients: are we detecting enough deep vein thrombosis? *J R Soc Med* 1989;82:203-5.
- Nordstrom M, Lindblad B. Autopsy-verified venous thromboembolism within a defined urban population - the city of Malmo, Sweden. *APMIS* 1998;106:378-84.
- Geerts WH, Heit JA, Clagett GP, Pineo GF, Colwell CW, Anderson FA, et al. Prevention of venous thromboembolism. *Chest* 2001; 119 Suppl 1:132S-75S.
- Rajaratnam G, Black NA, Dalziel M. Total hip replacements in the National Health Service: is need being met? *J Public Health Med* 1990;12:56-9.
- Madhok R, Lewallen DG, Wallrichs SL, Ilstrup DM, Kurland RL, Melton LJ, et al. Trends in the utilization of primary total hip arthroplasty, 1969 through 1990: a population-based study in Olmsted County, Minnesota. *Mayo Clin Proc* 1993; 68: 11-8.
- Quam JP, Michet CJ, Wilson MG, Rand JA, Ilstrup DM, Melton LJ, et al. Total knee arthroplasty: a population-based study. *Mayo Clin Proc* 1991;66:589-95.
- Seagroatt V, Tan HS, Goldacre M, Bulstrode C, Nugent I, Gill L. Elective total hip replacement: incidence, emergency readmission rate, and postoperative mortality. *Br Med J* 1991;303:1431-5.
- Collins R, Scrimgeour A, Yusuf S, Peto R. Reduction in fatal pulmonary embolism and venous thrombosis by perioperative administration of subcutaneous heparin: overview of results of randomized trials in general, orthopaedic and urologic surgery. *N Engl J Med* 1988;318:1162-73.
- Fletcher JP, Koultis J, Ockelford PA. Deep vein thrombosis prophylaxis: a survey of current practice in Australia and New Zealand. *Aus NZ J Surg* 1992; 62:601-5.
- Rodgers A, Gray H, MacMahon S. Pharmacological thromboprophylaxis in hip and knee surgery: a survey of New Zealand orthopaedic surgeons. *Aus NZ J Surg* 1994;64:167-72.
- Walker N, Rodgers A, Gray H. Changing patterns of pharmacological thromboprophylaxis use by orthopaedic surgeons in New Zealand. *Aus NZ J Surg* 2002; 72: 335-8.
- Ahmad HA, Geissler A, MacLellan DG. Deep venous thrombosis prophylaxis: are guidelines being followed? *Aus NZ J Surg* 2002; 72:331-4.
- Anderson FA, Audet AM. Physician practices in the prevention of deep vein thrombosis: the MassPRO DVT study. *Orthopaedics* 1996; 19 Suppl 1:9S-11S.
- Bratzler DW, Raskob GE, Murray CK, Bumpus LJ, Platt DS. Underuse of venous thromboembolism prophylaxis for general surgery patients. *Arch Intern Med* 1998;138:1909-12.
- Stratton MA, Anderson FA, Bussey HI, Caprini J, Comerota A, Haines ST, et al. Prevention of venous thromboembolism: adherence to the 1995 American College of Chest Physicians consensus guidelines for surgical patients. *Arch Intern Med* 2000;160:334-40.
- Arnold DM, Kahn SR, Shrier I. Missed opportunities for prevention of venous thromboembolism. An evaluation of the use of thromboprophylaxis guidelines. *Chest* 2001;120:1964-71.
- Nicolaidis AN, Breddin HK, Fareed J, Goldhaber S, Haas S, Kalodiki E, et al. Prevention of venous thromboembolism: International Consensus Statement: Guidelines compiled in accordance with the scientific evidence. *Int Angiol* 2001; 20:1-37.
- World Medical Association Declaration of Helsinki: ethical principles for medical research involving human subjects. *JAMA* 2000;284:3043-5.
- Goldhaber SZ, Dunn K, MacDougall RC. New onset of venous thromboembolism among hospitalized patients at Brigham and Women's Hospital is caused more often by prophylaxis failure than by with-

- holding treatment. *Chest* 2000; 118: 1680-4.
22. Borris LC, Lassen MR. Thromboprophylaxis with low molecular weight heparin after major orthopaedic surgery is cost effective. *Drugs* 1996; 52 Suppl 7:42-6.
23. Dunn CJ, Goa KL. Enoxaparin. A pharmacoeconomic appraisal of its use in thromboembolic prophylaxis after total hip arthroplasty. *Pharmacoeconomics* 1996; 10:179-90.
24. Dahl OE, Pleil AM. Investment in prolonged thromboprophylaxis with dalteparin improves clinical outcomes after hip replacement. *J Thromb Haemost* 2003; 1:896-906.
25. Anderson FA, Wheeler HB, Goldberg RJ, Hosmer DW, Forcier A, Patwardhan HA. Changing clinical practice: prospective study of the impact of continuing medical education and quality assurance programs on the use of prophylaxis for venous thromboembolism. *Arch Intern Med* 1994;54:669-77.
26. Davis DA, Taylor-Vaisey A. Translating guidelines into practice: a systematic review of theoretic concepts, practical experience and research evidence in the adoption of clinical practice guidelines. *Can Med Assoc J* 1997;157:408-16.
27. Balas EA, Weingarten LS, Gard CT, Blumenthal D, Boren SA, Brown GD. Improving preventive care by prompting physicians. *Arch Intern Med* 2000;160:301-8.

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