Venous thromboembolism prevention program implementation in a community oncology practice: a cohort study

Steven Ades,[a,*] Yonatan Resnick,[b] Jacob Barker,[c] Karlyn Martin,[a] Ryan Thomas,[a] Karen Libby,[c] John Winters,[b] and Chris Holmes[a]

[a]University of Vermont Cancer Center, 89 Beaumont Ave, Burlington, VT 05405, USA
[b]New England Cancer Specialists, 100 Campus Dr Unit 108, Scarborough, ME 04074, USA
[c]University of Vermont Medical Center, 111 Colchester Ave, Burlington, VT 05401, USA

The Lancet Regional Health - Americas 2024;38: 100866

Published Online xxx https://doi.org/10.1016/j.lana.2024.100866

Summary

Background While national guidelines recommend Venous Thromboembolism (VTE) risk assessment in cancer outpatients and consideration of pharmacologic prophylaxis in high-risk patients, prophylaxis rates are low in community oncology practices. A successful model for guideline implementation (the Vermont Model, VM) is validated in an academic tertiary oncology setting. We undertook an implementation study to determine the success of this model in a multi-site community oncology practice. The study objectives were to: 1) adapt the VM to the community practice setting; 2) implement the adapted VM into practice; and 3) evaluate clinical and implementation outcomes.

Methods The study was carried out in three phases: (1) Pre-implementation, a multidisciplinary team addressed the need to adapt the VM to the local context including electronic medical record (EMR) optimisation and clinician education; (2) implementation of the strategies adapted to the local context, informed by VM and adapted based on stakeholder feedback; (3) prospective evaluation of clinical and implementation outcomes at six months after implementation.

Findings Following creation of a comprehensive initiation roadmap for the adaptation of VM program to the community practice, 302 cancer outpatients initiating new treatment met inclusion criteria over a 6 month implementation period. VTE risk education was provided to 100% of patients, and 98% (296) of patients received a VTE risk assessment. Of 52 patients (18%) who scored as high risk based on a modified Khorana (Protecht) score, 14 (27%) initiated prophylaxis. Barriers to program adaptation included EMR optimization challenges and practice-level responsibility assignment, time constraints, concern about potential drug interactions, and financial & insurance issues.

Interpretation Implementation of a multidisciplinary VTE prevention model in the community-based oncology setting successfully increased VTE education and risk assessment rates. AC prophylaxis rates were modestly increased, highlighting the need to understand and address barriers to anticoagulant prophylaxis prescribing in this setting.

Funding Northern New England Clinical Oncology Society Research Funding Program.

Keywords: Venous thromboembolism prophylaxis; Community oncology; Ambulatory cancer care; Guideline implementation

Introduction

Venous thromboembolism (VTE) is a major cause of morbidity and mortality, especially in certain high-risk cancer populations. It is estimated that 5–20% of cancer patients develop a VTE, and this risk can be mitigated by using prophylactic anticoagulation.[1] Several professional organisations have issued recommendations for consideration of prophylactic anticoagulant (AC) use in cancer patients at high risk of VTE.[1–5] Recently, both oral apixaban and rivaroxaban have been studied in cancer patients at high risk of VTE and found to be safe and effective in reducing VTE rates.[6,7]

*Corresponding author.
E-mail address: steven.ades@med.uvm.edu (S. Ades).

Research in context

Evidence before this study

Venous thromboembolism (VTE) is a major cause of morbidity and mortality in high-risk cancer populations, and this risk can be mitigated by using prophylactic anticoagulation. Despite multiple guideline recommendations, compliance with anticoagulant (AC) prophylaxis is poor. One successful guideline implementation model is available and focuses on the academic practice environment but it was not known if there were successful guideline implementation models published for the community practice setting where most cancer patients receive treatment in the Unites States.

PubMed and MEDLINE were searched through March 1, 2020 for all studies utilizing the following search terms: venous thromboembolism, prophylaxis, guideline implementation, outpatient cancer treatment, and community practice. At the time, there were no publications meeting these criteria except for a retrospective, single-center cohort study of patients with pancreatic and gastric cancers examining rates of prophylactic anticoagulation prescription for eligible patients at high risk of VTE based on a validated risk score. Of 437 eligible patients, 41% were high risk, and none had an anticoagulation prescription for prophylaxis without an alternate treatment indication. The study also included a survey of oncology clinicians at the same institution regarding practice patterns and knowledge with respect to VTE risk assessment and primary thromboprophylaxis. Of 34 participating clinicians, two thirds were unfamiliar with the risk score or guideline recommendations, and 90% reported never or rarely employing VTE risk assessment. This search was updated prior to manuscript preparation, revealing a published online survey delivered to medical oncologists which reported three risk factors as strong considerations for initiating prophylaxis including prior VTE history, immobilisation and cancer type. The authors concluded that while respondents were aware of the VTE risk of cancer patients, awareness of current guideline recommendations was lacking. There are no published models for implementation of a thromboprophylaxis program in the community oncology practice setting. In sum, published evidence found a lack of guideline adherence across academic and community oncology practices.

Added value of this study

This cohort study is the first prospective guideline implementation study in a large multisite community oncology practice. This study captured key adherence and quality outcomes as well as barriers to implementation. Implementation successfully increased VTE education and VTE risk assessment rates, however, the AC prophylaxis rates remained modest with multiple clinician, patient, and health system barriers requiring attention to successfully prescribe anticoagulant prophylaxis in this setting.

Implications of all the available evidence

This study is the first to provide evidence-based guidance on guideline implementation in the community oncology setting to close the gap between societal recommendations and clinical practice. Barriers to successful outpatient thromboprophylaxis in high-risk cancer patient populations are emphasized. Future research will be needed to further validate this model and address barriers improve AC rates in diverse community oncology practices.

While there are multiple guidelines on who should receive AC, including the use of the validated Khorana score,[8] there have been hurdles in implementing the use of AC prophylaxis in clinical practice.[9] Based on a large cohort study at the University of Vermont, a thromboprophylaxis program (The Vermont Model) was created to increase the rate of prophylactic AC use in high VTE risk cancer patients through education of all patients, identification of high-risk individuals, and multidisciplinary involvement of stakeholders including haematologists, advanced-practice professionals, nurses, and pharmacists.[10] Key successes of the VM were the significant increase in outpatient VTE education to 95%, and 94% of high-risk individuals receiving VTE prophylaxis (Table 1). Other organisations have developed similar programs in both Canada and Turkey.[11–13]

The goal of this study is to implement and evaluate the VM in a new setting, namely, a community oncology practice setting, at which no formal VTE prevention program was previously in place. Specific aims include 1) adapt the VM to the community practice setting; 2) implement the adapted VM into practice with evaluation of implementation outcomes; 3) assess for barriers to successful implementation.

Methods

Study design

This prospective cohort study was designed as a research collaboration between the investigator team at the University of Vermont and collaborators at New England Cancer Specialists (NECS), a community oncology practice comprising 13 physicians, 20 nurses, 2 pharmacists, and 14 nurse practitioners at four separate sites in Southern Maine. Institutional Review Board approval was obtained with consent waiver prior to study initiation.

During a six-month pre-implementation phase, stakeholders including physicians, pharmacists, and advanced practice professionals from NECS met with

Academic model (Vermont Model)			Community oncology practice model		
Clinical components	Structure	Key personnel	Clinical components	Structure	Key personnel
Assessment of thrombosis & bleeding risk	EMR-based risk assessment tool	Nursing	APP assessment of thrombosis & bleeding risk	EMR-based risk assessment tool	APP
VTE education for all patients	Templated VTE education guide and EMR documentation	Nursing	VTE education for all patients	Templated VTE education guide and EMR documentation	APP
Referral of patients at high risk for VTE to thrombosis specialist	Standardized electronic referral process	Nursing	Same or subsequent day VTE Prevention High Risk Visit	VTE Prevention High Risk Note	APP
Pharmacy evaluation	Formal Drug interaction assessment	Pharmacist	Not implemented	Not implemented	
Consultation with thrombosis specialist: decision regarding prophylactic anticoagulation start	Thrombosis Action Plan template for patients initiating prophylaxis	Hematologist, Hematology APP or Pharmacist Clinician	VTE Prevention High Risk Visit: decision regarding prophylactic anticoagulation start	VTE Prevention High Risk Note	APP
Ongoing monitoring for VTE and bleeding	Follow-up clinical encounters	Oncologist or APP	Ongoing monitoring for VTE and Bleeding	Follow up clinical encounters	Oncologist or APP

APP, Advanced Practice Professional; VTE, Venous thromboembolism; EMR, Electronic medical record.

Table 1: **Comparison of the Vermont Model[10] for guideline implementation to prevent cancer-associated venous thromboembolism in the ambulatory setting with adapted community oncology practice model selected for NECS.**

the VM investigator leadership team to adapt the VM to the practice infrastructure already in place at NECS sites. This large community oncology practice did not have a formal AC prophylaxis program and practicing clinicians confirmed that this was not standard practice. An initiation roadmap for the application and integration of VM program at NECS was developed, which included a detailed flow algorithm for clinician education, how to perform VTE risk assessment, prophylaxis evidence review for decision-making around AC, and prescription where appropriate (Fig. 1). Operational elements were also addressed including estimates of added workload, ownership of educational elements, optimization of the EMR and note template creation with discrete fields to capture the various process elements. VTE prophylaxis clinical decision support

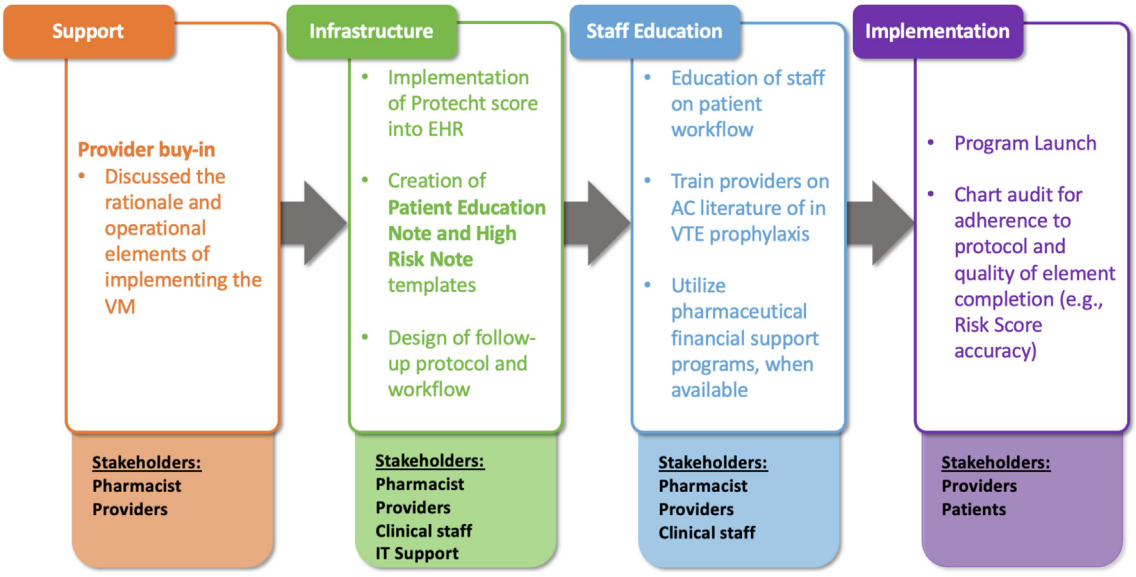

Fig. 1: **Process of introduction (pre-implementation) & implementation of Vermont Model at NECS**. NECS, New England Cancer Specialists; AC, anticoagulant.

was incorporated into the local EMR, including the addition of VTE prevention patient education within the standard Treatment Education Note, creation of a new High-Risk VTE Note template, AC options, and an EMR flowsheet to follow AC administration over time.

Modifications to the VM patient flow algorithm specific to the setting included creating a document with specific VM tasks and the persons or systems to address them at NECS (Fig. 2). The roadmap also included creation of additional resources needed to successfully implement the program at NECS practice sites such as clinician-facing educational materials, EMR elements and training sessions. Table 1 contrasts the VM with adapted NECS Community Oncology Model that we developed during the pre-implementation phase.

The adapted implementation strategy was initiated and prospective data was collected for six months. Data was captured by chart review by the NECS clinical team and entered into a secure database without identifiers, including patient age, sex, cancer type, individual components of the Protecht score (see section 3 of methods), bleeding events resulting in discontinuation of prophylaxis, need for an additional visit to complete education and risk assessment, and documentation of rationale for not initiating high-risk patients on AC. Implementation outcomes (Outcomes & Analysis section below) were captured directly from EMR review including modified templates, or clinicians on site who cared for this cohort.

Target population

Patients eligible to initiate the adapted VM were those with histologic confirmation of cancer requiring initiation of cancer directed therapy, as determined by the treating oncologist. Participants were included across all NECS practice sites during a six-month study period. Inclusion criteria were outpatients receiving initial systemic therapy for all malignancy types including, but not limited to lung, breast, head and neck, renal, pancreatic,

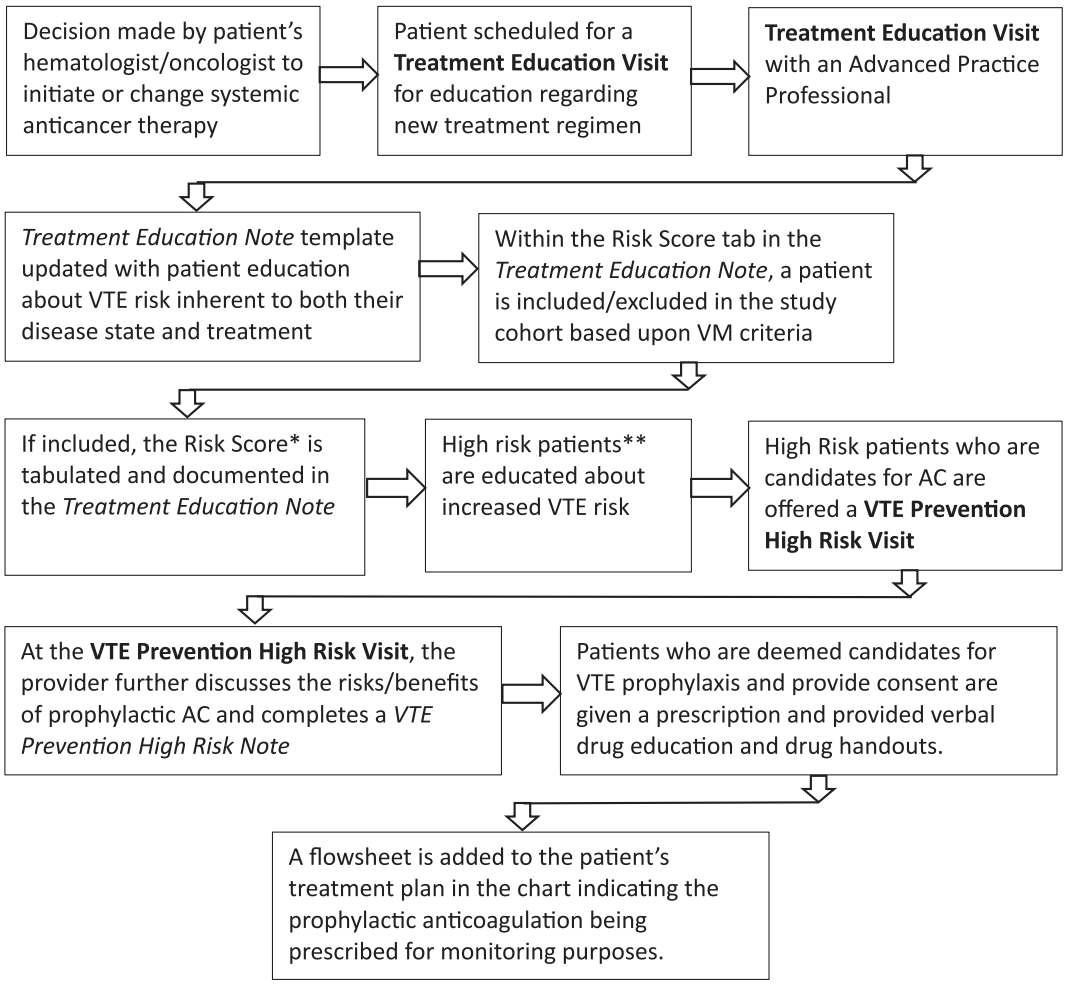

***Fig. 2:* Detailed implementation flow algorithm for target NECS patient population**. * modified Khorana (Protecht) score. ** Protecht ≥3 points. AC, anticoagulant; VTE, venous thromboembolism; VM, Vermont Model; NECS, New England Cancer Specialists.

upper and lower GI, gynaecologic, lymphoma, and urologic cancer. Exclusion criteria were those patients with brain tumours, leukaemia, those receiving radiation or hormonal therapy alone, those with a confirmed diagnosis of VTE at the time of risk assessment, and those who were receiving AC for another medical reason (e.g., atrial fibrillation). Anti-platelet therapy was allowed.

Risk assessment and AC management

Risk assessment was based on the Protecht score. The Protecht score consists of a modification of the Khorana score with addition 1 point for gemcitabine chemotherapy and platinum-based chemotherapy, respectively.[14] The Khorana score is a point-based risk score used to estimate the risk of incident VTE in ambulatory cancer patients. Points are attributed according to cancer type (stomach or pancreas [2 points], lung, lymphoma, gynaecologic, bladder, or testicular cancer [1 point]), platelet count $\geq 350 \times 10^9$/L (1 point), haemoglobin level <10 g/dL or using erythrocyte growth factors (1 point), leukocyte count $>11 \times 10^9$/L (1 point), and body mass index ≥ 35 kg/m^2 (1 point). Laboratory values were pretreatment values obtained prior to medical cancer treatment. The high risk of VTE during treatment was defined as ≥ 3 points.[15]

While the EMR was leveraged to capture requisite risk assessment data elements as able, the blood count elements ultimately had to be entered manually, and the Protecht score had to be manually calculated at the point of care during the Treatment Education Visit with the APP as the local EMR wouldn't support those functions. The assessment tool providing guidance on score calculation and risk stratification was embedded into the Treatment Education Note template.

During Treatment Education Visits, which were targeted to take place within an existing oncology appointment, clinicians provided information to patients about preventing and recognising VTE. In addition to educational intervention and risk assessment, Treatment Education Visits involved the identification of patients at high risk for VTE (Protecht score ≥ 3). For high-risk patients, educating providers were granted the flexibility to provide AC education either during the initial Treatment Education Visit, or preferably during a separate VTE Prevention High-Risk visit appointment. This preference for a separate VTE Prevention High-Risk visit acknowledges the complexity for patients of adding another medication with a narrow therapeutic index to a medication list that also now includes cancer directed and supportive care agents.

High-risk patients were offered prophylaxis with prophylactic dose apixaban (2.5 mg po twice daily), rivaroxaban (10 mg po daily), or low molecular weight heparin (40 mg SC daily) per the VM and according to national recommendations. Prophylaxis was recommended for the duration of systemic therapy. A manual chart of all prescriptions by one of the investigators (YR) included capture of adherence as well as dosage verification. Reasons for failure to initiate AC prophylaxis for high-risk score patients including refusal were captured based on manual chart review and aggregated. When AC was stopped, the reason for discontinuation was captured by manual chart review.

All risk scores were manually reviewed for accuracy on a monthly basis during the implementation period. These audits were not part of the screening process itself but served to address the fact that risk calculation was subject to human error. Errors were classified based on whether or not they led to inaccurate risk categorization with confirmation if the error led to inappropriate treatment.

Outcomes & Analysis

The primary outcome was VTE risk assessment performed on eligible patients (adoption). Secondary outcomes were: 1) patient VTE education rates, 2) AC prophylaxis rates for high VTE risk patients (effectiveness), 3) rates of AC discontinuation, 4) % of incorrect scores (fidelity), (5) barriers to implementation.

We set a target threshold to consider the successful implementation of the program at NECS, with target thresholds of: 1) VTE education rates >60% of eligible patients, 2) VTE risk assessments >60% of eligible patients, 3) VTE prophylaxis rates >25% in patients at high risk of VTE. Capturing thrombosis and bleeding events outside of those leading to AC discontinuation was considered outside the aims and scope of this study.

Regular meetings of team members from both sites were conducted as part of an iterative Plan-Do-Study-Act process continued throughout the project including aggregated dashboard metrics to inform the investigator team in real time of implementation successes and barriers. Post-implementation barriers were collected based on manual chart review with clarification from the treating clinician where necessary. They were group into system, provider and patient level categories. The study used descriptive statistics to analyse aggregated data.

Role of funding source

The Northern New England Clinical Oncology Society had no role in study design, data collection, data analysis, interpretation, or writing of the report.

Results

The six-month pre-implementation phase was successful with the development of a detailed flow algorithm covering operational aspects of implementation including clinician education, VTE risk assessment and prophylaxis options, and EMR and workflow optimisation (Fig. 1, Table 1).

Over a six-month period from November 2020 to May 2021, 765 consecutive patients initiating a new

systemic therapy at NECS completed Treatment Education Visits (Fig. 2). Fig. 3 is a flow diagram for the educational intervention, risk assessment, identification and prophylactic treatment of patients at high-risk for VTE. Of those, 302 (39.5%) patients met VM enrolment criteria. The mean age was 66 years and 154 (52%) were males (Table 2). Of 463 excluded patients, 401 (87%) were not receiving initial treatment and 62 (13%) initiated hormonal therapy alone (Fig. 3). As would be expected in a community oncology practice setting, the most prevalent malignancy types were non-small cell lung cancer (57, 19%) and breast (47, 16%). The highest VTE risk score contributors in this cohort included presence of high-risk disease state and platinum or gemcitabine based treatment (110, 37% each), and elevated white blood cell and platelet counts (47, 16% each).

Table 3 summarises the key outcomes. Adoption was assessed based on the completion of risk assessments which were documented in the EMR in 296 (98%) of eligible patients. 52 patients (18%) were categorised as high risk (Risk Score ≥ 3). Fidelity was assessed based on the accuracy of the Protecht Score classification. 18% of calculated scores did not match those calculated by the study team. In only three (1%) and nine (3%) cases did the risk score miscalculation lead to inaccurate high-risk or lower risk (<3) categorizations, respectively. In none of the three inaccurately calculated high-risk cases was AC inappropriately prescribed. Twenty patients (38.5%) required an additional separate high-risk VTE prevention clinic visit to address prophylaxis.

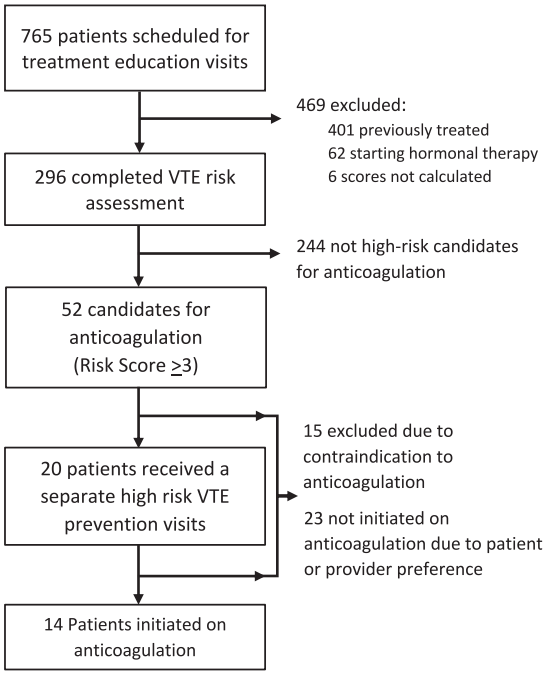

***Fig. 3:* Flow diagram for a patient at NECS with respect to education, risk assessment, and anticoagulation prescription**. NECS, New England Cancer Specialists.

Of the 52 high-risk patients, 14 (27%) initiated AC prophylaxis, including five pancreatic cancer, five non-small cell lung cancer and four bladder cancer patients. Average time from treatment start date to initiation of AC prophylaxis was 5.2 days (0–20 days). Rivaroxaban (10 mg daily) and apixaban (2.5 mg twice daily) were prescribed for ten patients and four patients, respectively. Five patients were reported as subsequently discontinuing AC due to clinically relevant non-major bleeding events for a total of nine patients on continued AC at the time of study closure.

Barriers

Barriers to implementation were identified during both pre-implementation and post-implementation. During pre-implementation, the main barriers included decision-making around who will provide the treatment education and when, as well as limits to the adaptability of the EMR with respect to automation of the risk calculation. There was also confusion regarding which cancers were considered high-risk (e.g., upper tract versus bladder cancer, gastroesophageal junction cancer versus gastric cancer), and expected duration of prophylaxis.

Post-implementation system level barriers included the requirement for ongoing EMR risk scoring tab optimization, higher than anticipated miscalculation rate in the VTE risk score identified by chart audit, and financial considerations that arose (insurance denial, expensive co-pays of AC).

Provider reasons for not starting AC for high-risk patients included concern for concomitant medications that increase risk of bleeding (e.g., aspirin/clopidogrel), current bleeding or high risk of bleed, planned procedures, provider preference or discomfort with a new supportive care paradigm, patient frailty or compliance concern, and clinician time constraints. Common reasons for patients not accepting prophylaxis included being overwhelmed at the time of offer, insurance denial or cost of medication, and personal preference. Excluding those with reasonable to absolute contraindications to AC (bleeding lesions or symptoms, concern regarding compliance, high fall risk), 37 high-risk patients (71%) were candidates for prophylactic AC with resulting AC prescription rate of 38% (14/37).

Discussion

In this study, we designed and implemented an adapted VM into a community oncology practice setting targeted to increase VTE prevention interventions in oncology practice, consisting of VTE risk-assessment for all patients starting systemic therapy, and starting prophylactic AC for high-risk patients.

We successfully completed a comprehensive pre-implementation planning phase. Following implementation, we saw successful 98% adoption of the intervention to conduct VTE risk-assessment. 27% % of high-risk patients were prescribed AC, and 17% remained on AC at the end of the study period. When accounting for patient exclusions from anticoagulation due to provider identified contraindications, the adjusted AC rate increased to 38%.

While multiple practice guidelines exist for the prevention of VTE in the ambulatory cancer patient population,[16] driven by increased incidence and high cost of VTE in this setting including decreased quality of life, increased bleeding, and higher risk of early mortality,[17,18] there is limited guidance on how best to implement these recommendations into practice.[10] Adoption of current guidelines to oncology practices remains elusive with limited published evidence, and studies reporting a large gap between recommendations and academic practice.[19–21] Even fewer data, if any, are available for implementation into community-based practice.

Our study demonstrated important barriers to uptake in a different practice setting. First, risk assessment in this study was challenging due to the inability to accurately auto-populate all the requisite data elements for a modified Khorana (Protecht) score into the local EMR, resulting in an erroneous risk calculation rate approaching one in five patients. Despite this, only a small fraction of the calculation errors would have impacted the decision-making around AC prophylaxis. Future validated risk stratification tools will benefit from simplicity to optimise accurate integration into practice. Other barriers identified included financial considerations, time constraints impacting productivity and clinic flow, and provider hesitancy despite pre-implementation training. We hypothesize that this may have reflected a lack of knowledge of how to assess or manage risk with concurrent anti-platelet agents and lack of familiarity with DOAC options and dosing. The challenge was further complicated by guideline idiosyncrasies with respect to risk calculation and absence of formal bleeding risk assessment guidance at the point of care. Importantly, current guidelines do not adequately address the duration of prophylaxis.[9]

Our approach was to adapt a successful academic model for risk-assessment and prophylaxis in cancer patients at high risk of VTE into a large community oncology practice setting. We conducted the pre-implementation phase to elicit necessary adaptations to the community-based setting. However, despite similar features of clinician education, outpatient identification of eligible patients for risk assessment, calculated risk-scores, and selection of a high-risk subset for timely AC prophylaxis, our rates of AC prophylaxis (27%) were far lower than the academic practice (94%). A critical difference in the adaptation of VM to the NECS community oncology practice setting was the elimination of haematology consultation to address VTE prophylaxis in high-risk patients. In the original study, 71% of patients identified as high-risk were referred for a haematology consultation for prophylaxis assessment, which resulted in much higher rates of prophylaxis.[10] We hypothesise that many clinician barriers, such as uncertainty in AC dosing or use of concurrent anti-platelet medications, were overcome by the involvement of a haematologist in the decision-making, a key element to the VM that cannot be easily replicated in non-academic settings. Additional challenges in the NECS community implementation strategy compared with the academic VM included a lack of prospective pharmacy review for potential drug interactions and challenges to the application of electronic data capture elements across different EMR platforms (EPIC to

	All included patients	High risk patients protecht Score: 3+	Intermediate risk patients protecht Score: 1-2	Low risk patients protecht Score: 0
Total # of patients	302[a]	52 (18%)	164 (55%)	80 (27%)
Mean age (years)	66.3	65.8	67.7	63.9
Male sex (%)	154 (52%)	31 (60%)	91 (55%)	30 (38%)
Cancer type prevalence (>5% of cohort)	• NSCLC: 57 • Breast: 47 • Non-Hodgkin Lymphoma: 20 • Bladder: 19 • Pancreatic: 15 • Head and Neck: 15	• Pancreatic: 13 • NSCLC: 12 • Bladder: 9 • Gastric: 4 • Esophageal: 3	• NSCLC: 43 • Breast: 14 • NHL: 13 • Head and Neck: 12 • CLL: 9 • Colorectal: 9	• Breast: 32 • Melanoma: 7 • Multiple Myeloma: 5 • Colorectal: 5 • NHL: 4 • Prostate: 4

NSCLC, non-small cell lung cancer; CLL, chronic lymphocytic leukemia. [a]Risk subset numbers add up to 296 overall and 152 male sex, representing the number eligible patients who had completed risk assessments with score calculations.

Table 2: **Cohort demographics and risk assessment.**

Assessed metric	Number of events N (%)
Total cohort VTE Education Rate (%)	765 (100)
VTE education rate (%) in eligible patients	302 (100)
VTE risk assessment (%) in eligible patients	296 (98)
i) Incorrect risk score	53 (17.9)
ii) Corrected scores leading to new high risk patients	10 (3.4)
iii) Corrected scores removing high risk patients	3 (1.0)
iv) Corrected scores not changing risk category	40 (13.5)
High risk VTE prevention visit rate (% of eligible high risk patients)	20/52 (38.5)
Initiated on anticoagulation (% of eligible patients)	14/52 (26.9)

VTE, venous thromboembolism.

Table 3: **Captured implementation metrics regarding education, risk assessment, and prophylactic anticoagulation.**

Flatiron OncoEMR in this case). The NECS intervention was primarily carried out by APP, but we are unable to determine the effect of this versus an oncologist and haematologist-driven VM.

Study limitations include a modest sample size of high-risk patients despite the use of the modified Khorana (Protecht) score which awards additional points for the type of systemic therapy, use of prophylactic anticoagulation prescription status in the chart as a proxy for adherence, and unstructured assessment of barriers based on chart review and direct communication with clinicians only in instances of nonadherence. It was outside of the study scope to capture the duration of prophylactic anticoagulation treatment and we did not evaluate low-risk patients to ensure they were not inappropriately prescribed anticoagulation.

In conclusion, despite significant strides in the establishment of best practices around the identification of ambulatory cancer patients at high-risk for VTE and availability of safe AC options in the outpatient setting, guideline implementation in practice remains challenging outside of large academic institutions with thrombosis and bleeding expertise. Efforts will need to focus on risk score simplification, increased guideline clarity on the duration of prophylactic AC, incorporation of medication-related bleeding risk assessment, development of patient-focused decision-making resources, and ultimately the development of dynamic risk scores to address the growing number of patients living with cancer as a chronic disease.

Contributors

The following authors contributed to this manuscript in one or more of the following roles:

A. conceptualization (SA, YR, JB, KL, JW,CH), B. data curation SA, YR, JW, CH), C. formal analysis SA, YR, CH), D. funding acquisition (SA, YR, CH), E. investigation (SA, YR, KL, CH), F. methodology (SA, YR, JB, KL, CH), G. project administration (SA, YR, KL, CH), H. resources (SA,YR, CH), I. software (SA, YR, JW, CH), J. supervision (SA, YR, KL, JW, CH), K. validation (SA, YR, JB, KM, RT, JW, CH), L. visualization (SA, YR, JB, CH), M. writing—original draft (SA, YR, KM, RT,CH), N. writing—review & editing (SA, YR, JB, KM, KL, JW, CH).

Data sharing statement

Patient-level data collected for the study was only accessed by treating providers from NECS, and will not be made available to others outside the NECS practice.

Declaration of interests

None of the manuscript author declare any competing or conflicts of interest. YR received a travel grant for travel & lodging support from the Northern New England Clinical Oncology Society (NNECOS) to attend the NNECOS 2022 Annual Meeting for an oral presentation of the study findings.

Acknowledgements

This study was made possible through a generous grant from the Northern New England Clinical Oncology Society Research Funding Program.

References

1 Lyman GH, Carrier M, Ay C, et al. American Society of Hematology 2021 guidelines for management of venous thromboembolism: prevention and treatment in patients with cancer. *Blood Adv*. 2021;5(4):927–974.
2 Farge D, Frere C, Connors JM, et al. 2022 international clinical practice guidelines for the treatment and prophylaxis of venous thromboembolism in patients with cancer, including patients with COVID-19. *Lancet Oncol*. 2022;23(7):e334–e347.
3 Key NS, Khorana AA, Kuderer NM, et al. Venous thromboembolism prophylaxis and treatment in patients with cancer: ASCO clinical practice guideline update. *J Clin Oncol*. 2020;38(5):496–520.
4 Munoz Martin AJ, Gallardo Diaz E, Garcia EI, et al. SEOM clinical guideline of venous thromboembolism (VTE) and cancer (2019). *Clin Transl Oncol*. 2020;22(2):171–186.
5 Wang TF, Zwicker JI, Ay C, et al. The use of direct oral anticoagulants for primary thromboprophylaxis in ambulatory cancer patients: guidance from the SSC of the ISTH. *J Thromb Haemost*. 2019;17(10):1772–1778.
6 Carrier M, Abou-Nassar K, Mallick R, et al. Apixaban to prevent venous thromboembolism in patients with cancer. *N Engl J Med*. 2018;380(8):711–719.
7 Khorana AA, Soff GA, Kakkar AK, et al. Rivaroxaban for thromboprophylaxis in high-risk ambulatory patients with cancer. *N Engl J Med*. 2019;380(8):720–728.
8 Khorana AA, DeSancho MT, Liebman H, Rosovsky R, Connors JM, Zwicker J. Prediction and prevention of cancer-associated thromboembolism. *Oncol*. 2021;26(1):e2–e7.
9 Ades S, Holmes CE. Implementing guidelines to prevent cancer associated thrombosis: how can we do better? *Res Pract Thromb Haemost*. 2023;7(1):100038.
10 Holmes CE, Ades S, Gilchrist S, et al. Successful model for guideline implementation to prevent cancer-associated thrombosis: venous thromboembolism prevention in the ambulatory cancer clinic. *JCO Oncol Pract*. 2020;16(9):e868–e874.
11 Diamantouros A, Kiss A, Papastavros T, U D, Zwarenstein M, Geerts WH. The TOronto ThromboProphylaxis patient safety initiative (TOPPS): a cluster randomised trial. *Res Social Adm Pharm*. 2017;13(5):997–1003.
12 Kandemir EA, Bayraktar-Ekincioglu A, Kilickap S. Assessment of adherence to cancer-associated venous thromboembolism guideline and pharmacist's impact on anticoagulant therapy. *Support Care Cancer*. 2021;29(3):1699–1709.
13 Pelletier R. Assessing the risk of venous thromboembolism (VTE) in ambulatory patients with cancer: rationale and implementation of a pharmacist-led VTE risk assessment program in an ambulatory cancer centre. *J Oncol Pharm Pract*. 2021;27(4):911–918.
14 Verso M, Agnelli G, Barni S, Gasparini G, LaBianca R. A modified Khorana risk assessment score for venous thromboembolism in cancer patients receiving chemotherapy: the Protecht score. *Intern Emerg Med*. 2012;7(3):291–292.
15 Khorana AA, Kuderer NM, Culakova E, Lyman GH, Francis CW. Development and validation of a predictive model for chemotherapy-associated thrombosis. *Blood*. 2008;111(10):4902–4907.
16 Streiff MB, Abutalib SA, Farge D, Murphy M, Connors JM, Piazza G. Update on guidelines for the management of cancer-associated thrombosis. *Oncol*. 2021;26(1):e24–e40.
17 Mahajan A, Brunson A, Adesina O, Keegan THM, Wun T. The incidence of cancer-associated thrombosis is increasing over time. *Blood Adv*. 2022;6(1):307–320.
18 Khorana AA, Mackman N, Falanga A, et al. Cancer-associated venous thromboembolism. *Nat Rev Dis Primers*. 2022;8(1):11.
19 Amirsadri M, Mousavi S, Karimipour A. The cost-effectiveness and cost-utility analysis of the use of enoxaparin compared with heparin for venous thromboembolism prophylaxis in medical inpatients in Iran. *Daru*. 2019;27(2):627–634.
20 Kandemir EA, Bayraktar-Ekincioglu A, Kilickap S. Oncologists' attitudes towards prophylaxis of cancer associated venous thromboembolism: a prospective, descriptive study. *J Oncol Pharm Pract*. 2021:10781552211035704.
21 Martin KA, Molsberry R, Khan SS, Linder JA, Cameron KA, Benson A 3rd. Preventing venous thromboembolism in oncology practice: use of risk assessment and anticoagulation prophylaxis. *Res Pract Thromb Haemost*. 2020;4(7):1211–1215.