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Alissa Payne
Grand Valley State University

Kelsey Boersma
Mary Free Bed Rehabilitation Hospital

Sarah Nechuta
Grand Valley State University

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Alissa Payne[1], Kelsey Boersma[2], Sarah Nechuta[1]

[1]Department of Public Health, College of Health Professions, Grand Valley State University, Grand Rapids, Michigan

[2]Center for Research & Innovation, Business Intelligence & Informatics, Mary Free Bed Rehabilitation Hospital, Grand Rapids, Michigan

Author notes

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Correspondence concerning this article should be addressed to Alissa Payne, MPH , email: payneal1@yahoo.com.

Abstract

Deep vein thrombosis (DVT) is an often underdiagnosed disease that can be life threatening for individuals. Currently, the best practice approach to assess the risk of venous thromboembolism (VTE) in patients within a rehabilitation hospital is unknown. We examined how well the Caprini risk assessment (CRA) score predicts VTE events (deep vein thrombosis (DVT), pulmonary embolism (PE)) within an inpatient rehabilitation hospital. Between January 2015 and October 2020, VTE events, the CRA Score, and risk factors were collected from a chart review conducted at Mary Free Bed Rehabilitation Hospital (MFB) among 3,091 patients. Results from the unadjusted logistic regression model showed that patients who have scores in the moderate-risk (odds ratios (OR)=0.076; 95% confidence interval (CI): 0.010-0.587) and high-risk categories (OR=0.961; 95% CI: 0.476-1.943) have lower odds of being diagnosed with DVT or PE. The highest risk category (≥ 5) showed an association between the CRA score and DVT or PE (OR=1.031; 95% CI: 0.540-1.967). When adjusting for medical service and discharge location, findings were similar among all four risk categories. The area under the receiver operating characteristic (ROC) curve, was 0.57 for the unadjusted model and increased to 0.61 for the adjusted model. Although a small association between the CRA score and prediction of VTE was noted, the low incidence of these events in the patient population limited study sample size and precision. This may be because almost all patients were on prophylaxis medication.

Keywords: Deep vein thrombosis, Venous thromboembolism, Pulmonary Embolism, Caprini risk assessment, Rehabilitation

Abbreviations:

Area under curve (AUC)

Caprini Risk Assessment (CRA)

Centimeters (cm)

Confidence interval (CI)

Deep vein thrombosis (DVT)

Length of stay (LOS)

Mary Free Bed Rehabilitation Hospital (MFB)

Odds ratio (OR)

Post-Stroke Rehabilitation Outcomes Project (PSROP)

Pulmonary Embolism (PE)

Receiver operating curve (ROC)

Sequential compression device (SCDs)

Spinal cord injury (SCI)

Thromboembolism-deterrent (TED) stockings

United States (U.S.)

Venous thromboembolism (VTE)

Background

Evaluating the Caprini Risk Assessment in an Inpatient Rehabilitation Facility

Deep vein thrombosis (DVT) is an often underdiagnosed disease and can be life threatening for individuals. DVT is a medical condition that occurs when a blood clot forms in a deep vein, typically developing in the lower leg, thigh, pelvis, or arm. While half of individuals have no symptoms at all, the most common symptoms of DVT are swelling, pain, tenderness, and redness of the skin (Centers for Disease Control and Prevention [CDC], 2020a). Risk factors for developing DVT include injury to a vein, slow blood flow, and certain chronic medical conditions, such as heart disease, lung disease, cancer, and inflammatory bowel disease (CDC, 2020a). The most serious complications of DVT happen when a part of the clot breaks off and travels through the bloodstream to the lungs, causing a blockage called a pulmonary embolism (PE) and if the clot is large enough it can stop blood from reaching the lungs causing death (CDC, 2020a). Venous thromboembolism (VTE), which includes PE and DVT, can occur in both the upper and lower extremities of the body (Yamashita et al., 2019). Upper extremity DVT is less common than lower extremity DVT, but it is still an area of concern especially with patients who have a central venous catheter, a higher rate of active cancer, or a recent hospitalization (Ageno et al., 2019). Additionally, it is well established that DVT of the lower extremities is common following major orthopedic surgeries to repair hip, knee, and spinal injuries since ambulation is difficult (Zixuan et al., 2020).

The exact number of individuals in the United States (U.S.) affected by DVT is unknown as no population-based registries for DVT exist, although as many as 900,000 people could be affected each year. Of those, roughly 100,000 will die due to improper DVT detection, leading to a PE, and ultimately death (CDC, 2020a). Sudden death is the first symptom in about 25% of people who have PE and approximately 10 to 30% of people will die within one month of diagnosis (CDC, 2020b). Among people who have had DVT, one third to one half will have long-term complications, such as post-thrombotic syndrome which includes symptoms of swelling, pain, discoloration, and scaling of the affected limb (CDC, 2020b). Many health care facilities measure thigh and calf circumference to predict complications of a DVT. Other approaches include specific risk assessments, such as the Caprini scale. Additionally, a D-dimer blood test has also been used to predict DVT. The diagnosis of DVT relies heavily on the use of objective tests because the signs and symptoms are not specific. Venography and other forms of ultrasonography are used in patients with clinically suspected DVT but are limited by the requirement for serial testing if the initial test is normal as well as by false positive results (Wells et al., 2005). False positive results have led to potentially unneeded procedures causing an extra burden on patients and healthcare professionals, as well as the economy due to unnecessary health care costs. Prediction and diagnosis of DVT are both important to determine within patients. Accurate and timely prediction of DVT enables non-invasive approaches to be implemented to avoid adverse outcomes associated with DVT. In summary, there is a critical need to accurately predict patients at risk of DVT to improve diagnosis and appropriate treatment for DVT and ultimately prevent VTE.

DVT Prediction

Caprini Risk Assessment

The Caprini risk assessment (CRA) has been evaluated in studies to see if there is a correlation between CRA scores and the incidence of DVT. Lobastov et al. (2015;2016) examined a group of high-risk patients who underwent abdominal (48%) or cranial and/or spinal (52%) surgery and found DVT in 28% of patients. The incidence of DVT was 2% in patients with a CRA score of 5 to 8, 26% in patients with a score of 9 to 11, and 65% in patients with a score of 12 to 15. The risk for DVT was increased 18.7-fold for patients with scores of 9 to 11 and 98.4-fold for scores of 12 to 15 compared with patients with scores of 5 to 8.

The CRA was also used to evaluate risk stratification for DVT among a sample of bedridden patients in 25 hospitals in China over 9 months (Bo et al., 2020). While a low overall incidence of 0.9% was found, risk by CRA score varied by classification group. More specifically, compared with the low-risk group, risk was 2.10-fold greater in the moderate-risk group, 3.34-fold greater in the high-risk group, and 16.12-fold greater in the highest-risk group with CRA score ≥ 9 (Bo et al., 2020). This demonstrates that the CRA can be effectively used to stratify patients into DVT risk categories, based on individual risk factors.

VTE can be a common and devastating postoperative complication. Hatchey et al. (2016) evaluated the CRA in postoperative patients, demonstrating that this high-risk patient population was more likely to have VTE. Based on the CRA protocol, those who are considered high-risk were prescribed postoperative prophylaxis medication and adherence to outcome audits were measured. A total of 126 patients were included with 24 patients scoring high-risk (19.2%), 60 were moderate-risk (48.0%), and 41 scored low-risk (32.8%). Patient adherence to post-discharge prophylaxis medication was 97.2% and the overall VTE was 2.3%, with no post-discharge VTEs or adverse bleeding events.

The CRA has also been compared to other prediction tools to see which method is more accurate when diagnosing DVT. Chen et al. (2018) reviewed data from a sample of hospitalized patients to compare the performance of the CRA and Padua risk assessments. The Padua risk assessment includes eleven items focusing on past medical history risk factors, age, and weight. Results showed that the CRA had a higher sensitivity (0.738 vs. 0.421) but a lower specificity (0.647 vs. 0.925) than the Padua risk assessment. The area under curve (AUC) value of the CRA (0.779 + 0.029) is significantly higher than the value of Padua risk assessment (0.635 + 0.031), which shows that the CRA has a better predictive ability for all patient data (Chen et al., 2018). Although the specificity of the Padua risk assessment was higher than the CRA, this study demonstrates that the CRA was significantly superior to the Padua model based on sensitivity and prediction of DVT in patients. DVT can lead to fatal consequences which stresses the importance of risk assessment models to screen high-risk patients.

Calf Measurements

Some DVT prediction techniques include calf measurements as a factor but many others do not. Calf measurements can be useful when diagnosing patients with symptomatic DVT. Research has shown that using a D-dimer test in addition to measuring an individual’s calf can help diagnosis or rule out DVT. Johanning et al. (2012) prospectively evaluated patients that were suspected of DVT by collecting data that assessed characteristics to include and exclude proximal DVT. Results showed that out of the 156 patients that were enrolled, elevated D-dimer levels (> 0.5 nanograms/milliliter) were observed in 22 of the patients diagnosed with DVT, which yielded a sensitivity of 95% and negative predictive value of 99%. Symptoms of swelling or pain were present in 94% of all patients and asymmetric calf swelling of more than 2.0 centimeters (cm) was noted in 14 of the patients.

Calf measurements are usually taken upon admission to healthcare facilities, depending on risk factors and symptoms. Ng et al. (2019) aimed to see if calf measurements at admission to an inpatient rehabilitation unit would have an impact on DVT detection. A total of 373 patients were admitted to the inpatient rehabilitation unit during a year. Collected measurements included compliance (if a calf measurement was recorded), if there was a difference of greater than 3 cm between two calves, if a venous doppler ultrasound was ordered for the affected leg, and if the outcome of the doppler study was positive. Only 6 patients (1.6%) did not have calves measured, achieving 98.4% compliance to measurement of calves by the admitting nurse. Only 1 patient had a difference in calf measurement and clinical exam significant to refer the patient for a doppler ultrasound. When the patient was further examined, results showed negative findings for DVT. Calf measurements alone may be a useful approach to screen for DVT in symptomatic patients. However, accuracy is limited, and additional measures need to be incorporated to predict and diagnosis DVT. Further, compliance throughout inpatient rehabilitation facilities and hospitals is extremely important, especially within high-risk populations.

When using simple methods with less information, such as only calf measurements to rule out DVT, missing data methods can be important to consider. Janssen et al. (2010) evaluated data in a sample of 804 patients who were suspected of having DVT. Only three variables were used to predict the presence of DVT; D-dimer level, difference in calf circumference, and history of leg trauma. Multiple imputation for missing data at random (ranging from 10% to 90%) was used. This approach showed less bias within the three variables and increased statistical power than complete case analysis, which did not include D-dimer levels in the analysis. While calf measurements are a way to predict DVT outcomes, this technique, in addition to a risk assessment scale or D-dimer, is needed to properly score patients risk of DVT.

Risk Factors

Research has identified many risk and protective factors for DVT that can be used to identify at-risk populations. Injury to a vein, often caused by fractures, severe injury, or major surgery (particularly involving the abdomen, pelvis, hip, and legs) is one of the most common factors contributing to DVT (CDC, 2020a). Furthermore, slow blood flow is also a common risk factor. This could be caused by confinement to bed (due to a medical condition or after surgery), limited movement (having an injured limb), sitting for a long time, and paralysis. Similar for many disorders, previous diagnosis, family history, age, and/or obesity may also impact risk of DVT. The chance increases even more for someone who has more than one of these factors at the same time (CDC, 2020a).

Inpatient Rehabilitation

The diagnosis and treatment of DVT is important not only in acute-care hospitals, but also, in rehabilitation hospitals. Almost all individuals who are receiving care at an inpatient rehabilitation hospital have one or more of the risk factors for DVT. Research studies have shown that DVT often occurs at rehabilitation hospitals within a few weeks of hospitalization, which could be because DVT is carried over from acute-care hospitals (Wada et al., 2013). A proper technique for DVT screening on admission to a rehabilitation hospital is useful for risk management.

Many patients are transferred to inpatient rehabilitation facilities on DVT prophylaxis, but protection is not always guaranteed. Patel et al. (2017) identified the incidence of DVT in high-risk patients who were already on DVT prophylaxis in an inpatient rehabilitation hospital. A retrospective chart review was used to find the patient's location of DVT, which was determined by venous doppler. Prophylactic measures prior to DVT development, patient's acute rehabilitation diagnosis, and measures taken once DVT was discovered were all recorded. A total of 22 patients admitted to the inpatient rehabilitation hospital developed DVT while on prophylaxis. Distribution of location of DVT included 13 patients with left lower extremity DVT, 8 patients with right lower extremity DVT, and 2 patients with unknown location of DVT. Even though patients are placed on DVT prophylaxis before being transferred from acute hospitals to inpatient rehabilitation hospitals, they are still at risk of developing DVT regardless of commonly used prophylactic medications. High-risk patients include those both post-stroke and post-orthopedic procedures, indicated that screening tools and risk assessments would still be valuable to manage the diagnosis of DVT (Patel et al., 2017).

While treatment for DVT is straightforward, the prevention process remains controversial. Zorowitz et al. (2005) launched the Post-Stroke Rehabilitation Outcomes Project (PSROP) database that was used to describe incidence, sequence, and trends in the prevention of DVT at a rehabilitation hospital. Of the 1,161 patients in the PSROP database, 383 (32.99%) patients without DVT and 8 (0.69%) with DVT had no documented orders for anticoagulant medications or any prophylaxis measures at all. Additionally, 65 (5.60%) patients had DVTs during their stay at the inpatient rehabilitation. Of 10 (0.86%) patients with DVTs in the common femoral vein, 4 (40%) were diagnosed within 24 hours of admission, and 9 (90%) of these 10 patients were classified as moderate or severe strokes. Since DVT is common at inpatient rehabilitation facilities, it is important for clinicians to learn and apply effective treatment protocols to prevent DVT events to allow more quality time for rehabilitation services.

The long-standing tradition at Mary Free Bed Rehabilitation Hospital (MFB) is to predict risk of complications from DVT by measuring the patient’s thigh and calf circumference. This is done upon admission by a Registered Nurse or nurse technician. The patient’s leg circumference is measured to determine if there is an increase greater than 2.5 cm between the two limbs. A difference in more than 2.5 cm requires an ultrasound and referral for treatment. This traditional practice has resulted in many false positives, which negatively impacts MFB patients and contributes to avoidable health care costs, ultimately adding unnecessary burden on providers and patients.

Prior research indicates that the CRA is a validated clinical prediction tool used to diagnose DVT. The CRA incorporates information based on patient medical history and includes age and weight as a factor. In addition to thigh and calf circumference measurements upon admission, MFB providers currently use the CRA. Once a risk score is generated from the assessment, a proper treatment option is determined for moderate, high-risk, and highest-risk DVT patients.

DVT is quite common within the U.S. population, especially within hospitals and inpatient rehabilitation facilities. National guidelines, as well as the Joint Commission and Centers for Medicaid and Medicare Services, have endorsed assessing DVT in medical patients using various risk assessment models (Grant et al., 2016). While there are many different prevention measures and precautions for DVT, health care facilities need to use the most accurate diagnosis approach to best guide appropriate measures to be implemented to reduce morbidity and mortality due to DVT.

A linear association between the CRA and DVT detection have been found in previous literature (Chen et al. 2018, Hatchey et al., 2016, Bo et al., 2020). However, previous studies in non-intensive care settings have been limited by small sample size. The large inpatient population at MFB presents a unique opportunity to evaluate the accuracy of DVT prediction methods and diagnosis among patients referred from acute-care hospitals. These patients may have been immobilized longer and have greater lengths of stay, putting them at higher risk for DVT. We evaluated the association of the CRA score and DVT/PE events among 3,091 inpatient individuals from MFB. The aim of this study was to determine the prediction accuracy of the CRA score alone and with additional clinical variables, such as medical service unit within the hospital and discharge location.

Methods

Study Design and Population

We conducted a retrospective chart review using the electronic medical records at MFB. The inclusion criteria for our study consisted of patients admitted to MFB for inpatient rehabilitation between 2015-2020. Patients from this chart review were also aged 18 and older. The original number of patients assessed in this chart review was 10,782 individuals. The CRA score is calculated within the patient’s chart and nurses are not obligated to fill out the risk factors that apply to each of the patients. Based on this protocol, there were 7,691 patients missing a CRA score. Due to this, we removed those patients for a better generalizable sample size of 3,091 individuals.

Medical Record Abstraction

The DVT chart review included various patient characteristics relating to factors that coincide with risk of DVT. Variables for this study included currently receiving prophylaxis, medications ordered or received, diagnosis of DVT or PE, medical service, discharge location, receiving anticoagulation, and CRA score (0-20). Diagnosis of DVT or PE is made by a physician after a patient receives a doppler, ultrasound, or computerized axial tomography scan. Clinical data was collected through a standardized data pull process used at MFB by trained medical abstractors.

Predictors and Covariates

The CRA scores were used as the predictor variable. CRA scores can range from 1-20, depending on patient risk factors. For the purpose of this study, we categorized the cut-points for these scores as follows: 0-1 (low risk), 2 (moderate risk), 3-4 (high risk), ≥ 5 (highest risk). This risk assessment and procedure is used by clinicians at MFB and aligns with cut-points from previous literature (Grant et al., 2016).

Covariates of interest for this study include receiving prophylaxis (yes/no), medications ordered or received (enoxaparin, aprixaban, heparin, warfarin, rivaroxaban, or none), diagnosis of DVT or PE (DVT, PE, or neither), medical service (spinal, stroke, orthopedics, cardiac, brain injury, other), discharge location (home, home with health care, acute-care hospital, other), and receiving anticoagulation medication (yes/no). Receiving prophylaxis included medication and compression devices, such as thromboembolism-deterrent (TED) stockings and sequential compression device (SCDs).

Outcomes

Our outcome variable of interest was the clinical event of DVT or PE. We categorized this variable as DVT, PE, or neither. DVT and PE events are diagnosed by doppler, ultrasound or computerized axial tomography scan. DVT prophylaxis used to prevent these outcomes includes an algorithm used by physicians and nurses. The algorithm is associated with each patient's risk score. If a patient is considered low risk (0-1), they are encouraged to ambulate. If a patient is considered to be moderate, high, or highest risk, the patient is given a certain pharmacological anticoagulation. If the patient is unable to receive anticoagulation medication due to a current contradiction (active/recent bleeding), mechanical prophylaxis is recommended (TEDs, SCDs). Once the contradiction is resolved, patients are then ordered anticoagulation medications. For those at highest risk, mechanical prophylaxis as well as anticoagulation medications are highly advised. For a confirmed diagnosed of DVT or PE, the patient is assessed to see if they require transfer to acute-care for venodynamic stabilization or imitation of thrombolytic therapy. If the patient is stable, they will remain in the inpatient rehabilitation facility and receive pharmacologic anticoagulation.

Statistical Analysis

Descriptive statistics were used to obtain the percentage and frequency of patients who had DVT, PE, the CRA scores, and the other covariates. We looked at the overall distributions and then distributions by the study outcome. We used binary logistic regression to estimate odds ratios (ORs) and 95% confidence intervals (CIs) for each clinical predicator and the CRA score. We then determined factors that best predict the odds of accuracy for the use of the CRA score. A receiver operating characteristic curve (ROC) was used to determine the specificity and sensitivity of the current risk assessment method used at MFB. One participant missing medical service and three participants missing discharge location were excluded from the logistic regression models and ROC curves. All analyses were performed using SAS 9.4. P-values less than 0.05 and confidence intervals containing 1.0 were considered statistically significant.

Results

Between January 2015 and October 2020, data on 3,091 eligible patients from MFB were collected. Based on the location and medical service within the hospital, most patients were located in the spinal injury unit (n=672, 21.75%), stroke unit (n=645, 20.87%), and the brain injury unit (n=330, 5.34%). In addition, many patients were receiving prophylaxis (n=3048, 98.61%) and receiving anticoagulants (n=2654, 85.86%) (**Table A1**).

A DVT event occurred in 66 patients while a PE event occurred in 16 patients. Among those who were diagnosed with DVT many were in the spinal injury unit (n=16, 24.25%) or other unit (n=32, 46.42%) with similar results for those who had PE. The most common anticoagulant medications administered to patients with DVT or PE was found to be enoxaparin, warfarin, and heparin. Results for discharge location among patients with DVT or PE were found to be similar among both diagnoses. Patients with DVT were most likely to be discharged home with health care (n=27, 40.52%) or discharged home without health care (n=21, 31.82%). Those diagnosed with PE were most likely discharged home with health care (n=6, 37.50%) or discharged to an acute-care hospital (n=5, 31.25%). Receiving prophylaxis and anticoagulation medications rates were extremely high for both DVT and PE patients. Results from the CRA score show that most patients diagnosed with DVT had a risk score ≥ 5 (n=36, 54.55%) and patients diagnosed with PE had a risk score of 2 (n=8, 50.00%) or 0-1 (n=5, 31.25%) (**Table A2**).

Results from the unadjusted logistic regression model showed that patients who have CRA scores in the moderate-risk (OR=0.076; 95% CI: 0.010-0.587) and high-risk categories (OR=0.961; 95% CI: 0.476-1.943) have lower odds of being diagnosed with DVT or PE (**Table A3**). CRA scores that were among the highest-risk category (≥ 5 scores) showed an association between the assessment model and a DVT or PE event, but this was not statistically significant (OR=1.031; 95% CI: 0.540-1.967). While results showed a small association, the ROC graph from the unadjusted model showed low accuracy with the CRA diagnosing DVT/PE (AUC= 0.5707) (**Figure A1**). Furthermore, results also showed both low sensitivity (54.9%) and specificity for the CRA (53.4%).

When adjusting for medical service and discharge location, findings were similar among all four risk categories (**Table A4**). Moderate-risk (OR=0.073; 95% CI: 0.009-0.565), high-risk, (OR=0.922; 95% CI: 0.451-1.882) and highest-risk (OR=0.983; 95% CI: 0.983-1.899) categories were found to have lower odds of being diagnosed with DVT or PE when compared to the low-risk category (0-1). CRA scores that were among the highest-risk category (≥ 5) showed an association between the assessment model and predicting DVT or PE, but this was also not statistically significant (OR=1.031; 95% CI: 0.540-1.967). Similarly, the ROC graph from the adjusted model still showed low overall accuracy, but AUC results increased to 0.6139 and sensitivity was 60.9%, while specificity was 43.6% (**Figure 2A**).

Discussion

Summary of Results

In this study of 3,091 inpatient rehabilitation patients at MFB hospital, we found that the CRA was associated with predicting DVT or PE in the moderate-risk category, but other categories were not statistically significant. When adjusting for medical service unit and discharge location, similar results were found, where DVT or PE in the moderate-risk category was found to be the only statistically significant category. Almost all patients who were diagnosed with DVT or PE were found to be on a prophylaxis or anticoagulation medication. The overall diagnostic accuracy of the CRA in both unadjusted and adjusted models was low and due to small sample size, precision was also limited.

Comparison to Previous Literature

Prophylaxis use has become a standard of care at MFB for nearly all inpatient admissions, regardless of diagnosis. However, prophylaxis use is not a metric within the CRA and confounds the diagnostic accuracy of this assessment when screening for high-risk individuals for DVT. Similar results were found in a retrospective dataset analysis among hip fracture patients where confounding variables associated with receipt of extended DVT prophylaxis may have influenced the study outcomes (Durand et al., 2018). This study indicated that confounders may have been related to preoperative patient comorbidity status, and that patients receiving extended DVT prophylaxis were generally healthier at baseline (Durand et al., 2018). In the study conducted by Bahl et al. (2010), pharmacologic prophylaxis increased as patient risk increased and results showed that adherence to the prophylaxis guidelines protected patients from VTE, but effect was not statistically significant. This may be because type and frequency but not the duration of prophylaxis was included in the model. However, after adjusting for prophylaxis, the mean probability of VTE doubles when risk level increased from moderate to high and from high to highest. This may have been the case for our study, but we were unable to adjust for prophylaxis given that almost all study participants used prophylaxis.

Descriptive results showed that patients located in the SCI unit had higher rates of DVT event (24.25%) compared to other units in the hospital. On average, SCI patients at MFB have the longest length of stay, which is roughly 4-6 weeks, where stroke patients typically have a significantly shorter length of stay (7-10 days). Studies have shown that DVT can develop within 7.5 ± 2.2 days in patients with SCI and that DVT occurs more often with a more severe paralysis (Matsumoto et al., 2015; Piran & Schulman, 2016). This research demonstrates symptomatic DVT is a frequent complication with SCI patients, which make up most of the patient population in inpatient rehabilitation hospitals.

According to Portney and Watkins (2015), "The ROC curve is plotted on a square with values of 1.0 for sensitivity and 1- specificity at the upper left and lower right corners, respectively. A perfect test instrument will have a true positive rate of 1.0 and a false positive rate of zero, resulting in a curve that essentially fills the square. A non-informative curve occurs when the true positive and false positive rates are equal, which means that the test provides no better information than a 50:50 chance". At MFB, the AUC threshold for acceptable used is 0.70, with a positive likelihood ratio over 5 and a negative likelihood ratio less than 0.2. When interpreting Figure A1, *Results of ROC among patients from MFB DVT chart review*, we can discern that the CRA has no better clinical utility in predicting DVT than flipping a coin (AUC= 0.5707; sensitivity=54.9%; specificity=53.4%). When interpreting Figure A2, *Adjusted results of receiver operating characteristic curve (ROC) among patients from MFB DVT chart review*, we can distinguish that the CRA offers a slight improvement over unadjusted results, but still under the AUC threshold for acceptable use (AUC=0.6139; sensitivity=60.9%; specificity=43.6%). Prior research of predictive modeling revealed a consistent linear increase in VTE for CRA scores between 1 and 10, while receipt of pharmacologic prophylaxis resulted in a modest decrease in VTE risk (Grant et al., 2016). Similar to our study, the low overall incidence of venous thromboembolism led to large estimates of numbers needed to treat to prevent a single VTE event.

Strengths and Limitations

Our study has several limitations. First, confounding variables associated with receipt of DVT prophylaxis may have influenced these results, since anticoagulation medications significantly reduce the risk of a VTE event. In addition, the fact that the data collection was retrospective, lead to reliance on documentation and imaging studies to confirm VTEs, and inpatient prophylaxis. Second, the CRA score variable had several missing scores, which drastically reduced our sample size from 10,782 to 3,091 patients. This also reduced the number of DVT/PE events that were diagnosed but did not include a CRA score. Third, our study was also missing general demographic characteristics such as age, gender, and race/ethnicity. Therefore, we were not able to adjust for these important potential confounding factors in our adjusted models or provide descriptives on that age, gender, and race/ethnicity characteristics of our study population.

Despite these limitations, our study has several strengths. Our data was collected through a review of individual medical records by trained abstractors, which provides a high level of accuracy within the data itself. Furthermore, the use of pharmacologic prophylaxis may explain the low incidence of VTE events at MFB indicating the need for continued use based on patient symptoms and recommendations.

Conclusions and Future Research

The assessment, diagnosis, and treatment of DVT remains a significant problem for hospitalized patients. The risk of DVT is even more significant when patients are discharged from the hospital to inpatient rehabilitation facilities. These patients can have multiple risk factors that predispose them to a DVT or PE event. A variety of prophylaxis strategies can be used to decrease the risk of developing DVT. The method of prophylaxis used should be based on individual patient characteristics.

Screening assessments that have been validated and provide high positive predicative value in acute-care settings are not always the most applicable assessments to use for the inpatient rehabilitation patient population. While the CRA has low diagnostic accuracy in predicting true positive rates of DVT at MFB, this does not affect the long-term outcome of evaluating and choosing another screening tool or option for assessing DVT risk at inpatient admission and ongoing monitoring for inpatient rehabilitation patients. Further research is needed to assess what other complimentary or separate screening measures may be used to provide better diagnostic accuracy for this unique patient population. such as compression ultrasounds, or D-dimer tests.

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Appendix A

Table A1

Medical service, medications, ambulation, and prophylaxis use among patients from MFB DVT chart review (n=3,087)

Variables	Frequency, n	Percent, %
Medical Service		
Amputee	165	5.34
Brain Injury	330	10.68
Cardiac	137	4.43
Spinal	672	21.75
Stroke	645	20.87
Orthopedics	165	5.34
Other	975	35.98
Anticoagulant Medications Received		
Enoxaparin	1583	51.21
Apixabin	332	10.74
Heparin	436	14.11
Warfarin	185	5.99
Rivaroxaban	96	3.11
Fondaparin	9	0.29
Dabigatran	13	0.42
None	437	14.14
Discharge Location		
Home	1081	38.51
Home with Health Care	1344	40.23
Skilled Nursing Facility	177	6.47
Acute-Care Hospital	450	14.56
Other	214	1.20
Receiving Prophylaxis		
Yes	3048	98.61
No	43	1.39
Receiving Anticoagulation		
Yes	2654	85.86
No	437	14.14
DVT/PE		
DVT	66	2.14
PE	16	0.52
Neither	3009	97.25
Caprini Risk Score		
0-1	397	12.84
2	423	13.68
3-4	825	26.69
≥ 5	1446	46.78

[b]Excludes 1 participant missing medical service and 3 participants missing discharge location.

Table A2

Patient Characteristics by DVT Event Outcome (n=3,087)

	Outcome		
	DVT N=66	PE N= 16	Neither N=3009
Medical Service, n (%)			
Amputee	0	0	165 (5.49)
Brain Injury	6 (9.09)	3 (18.75)	321 (10.67)
Cardiac	0 (2.05)	0	137 (4.45)
Spinal	16 (24.25)	2 (12.50)	654 (21.75)
Stroke	7 (10.61)	0	638 (21.21)
Orthopedics	5 (7.58)	2 (12.50)	158 (5.25)
Other	32 (46.42)	9 (56.25)	934 (26.47)
Anticoagulant Medications Received, n (%)			
Enoxaparin	32 (48.38)	8 (50.00)	1543 (51.28)
Apixabin	10 (15.15)	2 (12.50)	320 (10.63)
Heparin	8 (12.12)	2 (12.50)	426 (14.16)
Warfarin	10 (15.15)	2 (12.50)	173 (5.75)
Rivaroxaban	5 (7.58)	2 (12.50)	305 (3.39)
Fondaparin	0	0	9 (0.30)
Dabigatran	0	0	13 (2.96)
None	1 (1.52)	0	436 (14.49)
Discharge Location, n (%)			
Home	21 (31.82)	4 (25.00)	1056 (35.11)
Home with Health Care	27 (40.52)	6 (37.50)	1312 (43.62)
Skilled Nursing Facility	5 (7.58)	1 (6.25)	171 (5.68)
Acute-Care Hospital	13 (19.70)	5 (31.25)	432 (14.36)
Other	0	0	37 (1.23)
Receiving Prophylaxis, n (%)			
Yes	66 (100.00)	40 (100.00)	2966 (98.57)
No	0	0	43 (1.43)
Receiving Anticoagulation, n (%)			
Yes	65 (98.48)	16 (100.0)	2573 (85.51)
No	1 (1.52)	0	436 (14.49)
Caprini Risk Score, n (%)			
0-1	12 (18.18)	5 (31.25)	385 (12.79)
2	1 (1.52)	8 (50.00)	422 (14.02)
3-4	17 (25.76)	1 (6.25)	801 (26.62)
≥ 5	36 (54.55)	2 (12.50)	1401 (46.56)

[b]Excludes 1 participant missing medical service and 3 participants missing discharge location.

Table A3

Results of Binomial Logistic Regression Examining the Caprini Risk Assessment Score in Predicting DVT/PE Events Among Patients from MFB DVT Chart Review (n=3,091)

Caprini Risk Score	DVT/PE Event	
	Unadjusted OR	(95% CI)
0-1 (Low-risk)	1.00	(reference)
2 (Moderate-risk)	0.076	(0.010-0.587)
3-4 (High-risk)	0.961	(0.476-1.943)
≥ 5 (Highest-risk)	1.031	(0.540-1.967)

Abbreviations: Confidence Interval (CI), Deep Vein Thrombosis (DVT), Odds Ratio (OR), Pulmonary Embolism (PE)

Figure A1

Results of receiver operating characteristic curve (ROC) among patients from MFB DVT chart review

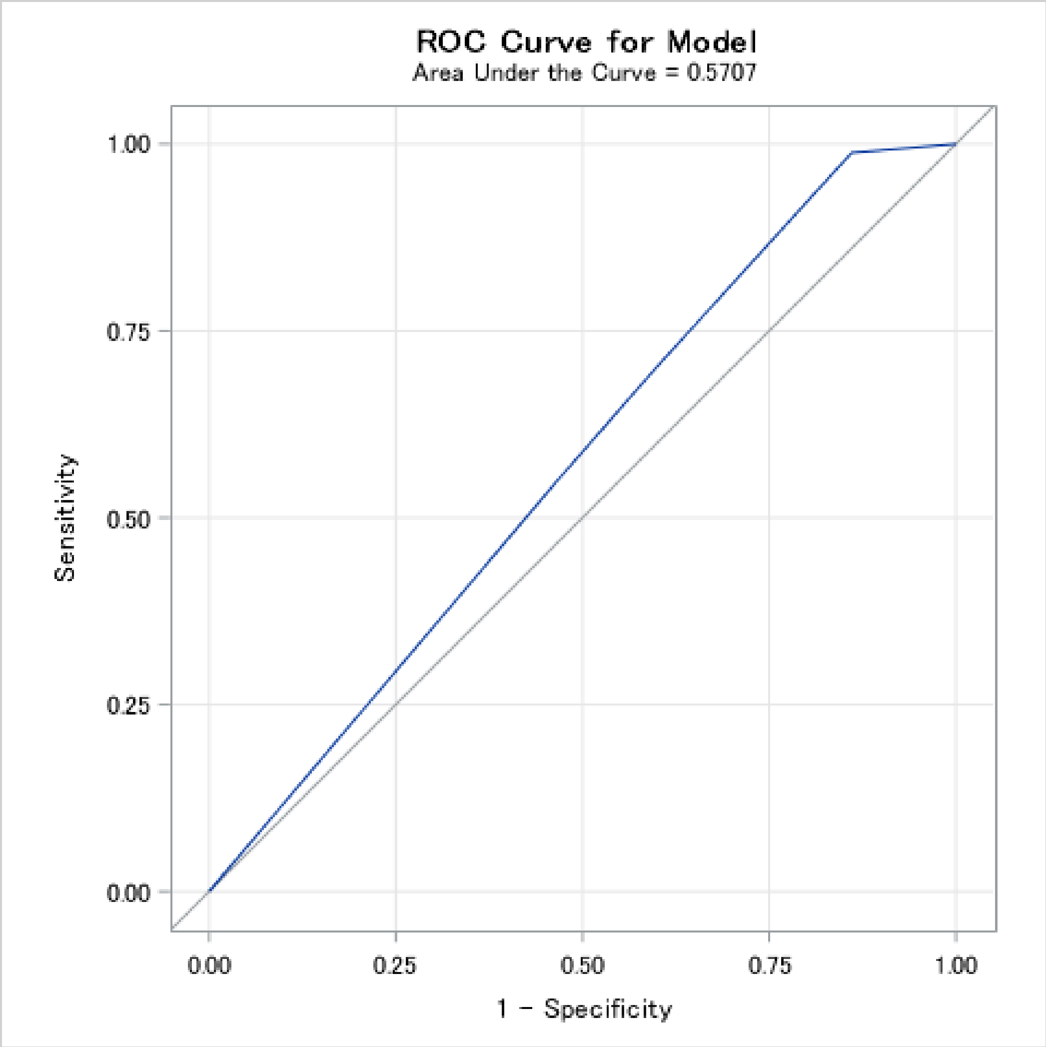

Table A4

Results of Adjusted Binary Logistic Regression Examining the Caprini Risk Assessment Score in Predicting DV/PE Events Among Patients from MFB DVT Chart Review (n=3,087)

Caprini Risk Score	DVT/PE Event	
	Adjusted OR[a]	(95% CI)
0-1 (Low risk)	1.00	(reference)
2 (Moderate risk)	0.073	(0.009-0.565)
3-4 (High risk)	0.922	(0.451-1.882)
≥ 5 (Highest risk)	0.983	(0.983-1.899)

Note. Table excludes 1 participant missing medical service and 3 participants missing discharge location
Abbreviations: Confidence Interval (CI), Deep Vein Thrombosis (DVT), Odds Ratio (OR), Pulmonary Embolism (PE)
[a]Adjusted for medical service and discharge location.

Figure A2

Adjusted results of receiver operating characteristic curve (ROC) among patients from MFB DVT chart review