Original Article

Caprini versus Padua venous thromboembolism risk assessment scores

A comparative study in hospitalized patients at a tertiary center

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ABSTRACT

الأهداف: لتقييم ومقارنة نماذج تقييم المخاطر بين كابريني و بادوا للتنبؤ بالجلطات الدموية الوريدية لدى المرضى المنومين في المستشفى.

المنهجية: أُجريت هذه الدراسة الرجعية في مستشفى جامعة الملك عبد العزيز بجدة، وشملت الدراسة 28 مريضًا من مرضى الجلطات الدموية الوريدية و450 مريضًا من غير المصابين بالجلطات الدموية الوريدية للمرضى المنومين في المستشفى في عام 2019. وتم الحصول على تفاصيل تقاريرهم الطبية، الديموغرافية، الإشعاعية، والتفاصيل الأساسية من سجلاتهم الطبية. بعد ذلك قمنا بمقارنة نتائج كابريني – التي تم حسابها عند تنويم المريض - ونتائج بادوا - المحسوبة رجعياً - لقدرتها على التنبؤ بالجلطات الدموية الوريدية. ثم تم حساب درجة المخاطر التراكمية عن طريق إضافة الدرجات الفردية لكل عامل خطر. قمنا أيضًا بتحليل الحساسية والنوعية والدقة التشخيصية لنماذج تقييم المخاطر بين كابريني و بادوا.

النتائج: أظهرت النتائج اختلافات كبيرة بين عوامل الخطر للمرضى الذين يعانون من الجلطات الدموية الوريدية. فإرتبطت الإصابة السابقة بجلطة وريدية بارتفاع نسبة خطر الإصابة بجلطة وريدية اخرى (28.6%)، كما أن قلة الحركة أو المشي (57.1%)، والعدوى الحادة (25%)، وارتفاع درجة تقييم كابريني (50%)، ودرجة تقييم بادوا العالية (64.3%) ساهمت في زيادة نسبة خطر الإصابة بالجلطة الوريدية ($p<0.05$). كما كانت حساسية درجة تقييم كابريني (96%) أعلى من حساسية درجة تقييم بادوا (64.3%)، كما أيضا كانت الخصوصية (92.1% مقابل 46.9%)، والقيمة التنبؤية الإيجابية (93% مقابل 7%)، والنوعية (94.1% مقابل 47.9%) أعلى في تقييم كابريني. كما كانت نوعية تقييم درجة كابريني أعلى من تقييم درجة بادوا في أقسام الرعاية الحرجة، وأمراض النساء والتوليد، والجراحة. ولكن أظهر تقييم كابريني أدنى مستوى من الخصوصية في القسم الطبي.

الخلاصة: أظهرت نماذج تقييم المخاطر في كابريني حساسية ونوعية ودقة تنبؤية أعلى من نماذج تقييم المخاطر في بادوا؛ وبالتالي ميزت درجة تقييم كابريني معامل خطر الإصابة بالجلطات الدموية الوريدية المنخفضة والعالية لدى المرضى المنومين في المستشفى.

Objectives: To assess and compare the Caprini and Padua risk assessment models (RAMs) for predicting venous thromboembolism (VTE) in hospitalized patients.

Methods: We retrospectively reviewed 28 VTE and 450 non-VTE patients hospitalized at King Abdulaziz University Hospital, Jeddah, Saudi Arabia, in 2019. Their baseline medical, demographic, and radiological reports were recorded. We compared Caprini scores (defined at admission) and Padua scores (calculated retrospectively) for their ability to predict VTE. A cumulative risk score was created by adding the individual scores for each risk factor. We also analyzed the sensitivity, specificity, and diagnostic accuracy of the RAM scores.

Results: Major differences in risk factors were shown between patients with and without VTE. Previous VTE was significantly associated with a higher risk of VTE (28.6%), as was reduced mobility (57.1%), acute infection (25%), high Caprini score (50%), and high Padua score (64.3%, $p<0.05$). The sensitivity of the Caprini score (96%) was higher than that of the Padua score (64.3%), as was the specificity (92.1% vs. 46.9%), positive predictive value (93% vs. 7%), and accuracy (94.1% vs. 47.9%). The specificity of the Caprini score was higher than that of the Padua score in Critical Care, Gynecology/Obstetrics, and Surgical departments. The Caprini RAM showed the lowest level of specificity in the medical department.

Conclusion: The Caprini RAM demonstrated higher sensitivity, specificity, and predictive accuracy than did the Padua RAM and thus distinguished low and high VTE risk in hospitalized patients.

Keywords: venous thromboembolism, deep vein thrombosis, pulmonary embolism, Caprini score, Padua score

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Venous thromboembolism (VTE) is a serious health concern in low-, middle-, and high-income countries, with the incidence increasing with age.[1,2] The global incidence rate of VTE in 2010 was estimated to be 115-269 per 100,000.[2,3] In New Zealand, the annual incidence rate of VTE between March 2004 and June 2009 was 81.6 per 100,000, with Europeans in general having a higher incidence rate.[4] More than half a million adults were hospitalized for VTE yearly from 2007-2009 in the United States (US), with an annual average of 348,558 deep vein thrombosis (DVT) hospitalizations, 277,549 pulmonary embolism (PE) hospitalizations, and 78,511 hospitalizations for both.[1] Another study in the US noted that more than 13,000 VTE events in hospitalized patients occurred, with the incidence rate increasing over the years from 2013-2021.[5] The incidence of VTE ranged from 11-88 cases per 10,000 among hospitalized patients in a systemic review of 9 studies that used Asian hospital registries.[6] The number of confirmed VTE cases among patients in a study that included 7 major hospitals over one year in Saudi Arabia (SA) was found to be 1241, with DVT estimated to constitute 58.3% of cases, PE 21.7%, and both in 20%, with a mortality rate of 14.3%.[7] A study by Alanazi et al[8] at King Abdulaziz University Hospital, Jeddah, SA, from October 2016 to March 2017 found that the incidence of DVT was 18% among elderly hospitalized patients. Although the incidence and mortality rates of VTE are growing in developing countries, they have improved in developed countries.[3] Venous thromboembolism causes serious complications, including post-thrombotic syndrome and chronic thromboembolic pulmonary hypertension.[9] The economic impact of treating VTE is high, with VTE readmission being more costly than initial admission.[10]

The burden of VTE can be reduced by using risk assessment models (RAMs), current guidelines recommending that all patients be assessed for risk of VTE.[11] Many VTE RAMs have been introduced, but Caprini and Padua are commonly used.[12,13] There is no evidence to support the superiority of one particular RAM over another.[14] In a retrospective study from China, Caprini was noted to be an effective predictive tool for VTE in the maternal population during the peripartum and postpartum periods.[15] In addition, Joseph et al[16] noted that Caprini has high predictability among surgical patients. Although the Caprini score has higher sensitivity and predictive ability than the Padua score has, it has lower specificity.[11] The Padua score can be calculated more easily than the Caprini score due to the lower number of parameters that need to be evaluated in Padua.[17,18] Caprini and Padua RAMs had low predictive ability for VTE, however, in an unselected population of hospitalized patients after admission at 30, 60, or 90 days.[19]

In this study, we aimed to assess which RAM scoring assessment had higher predictability in our patient population. This research may help improve the ability to predict VTE in hospitalized patients.

Methods. This retrospective study included 478 patients hospitalized in different departments at King Abdulaziz University Hospital (KAUH), Jeddah, SA, between January and December 2019. All patients had undergone radiological evaluation for VTE with Doppler ultrasonography (unilateral or bilateral), computed tomography (CT) pulmonary angiography, or both. Patients who did not have a VTE risk assessment score upon admission, that is, the Caprini score, were excluded from the study.

Study data were gathered by reviewing the patients' medical records, medical background, age, computed body mass index, VTE prophylaxis, and radiological evaluation reports.

The study was approved by the ethical committee at the Biomedical Ethics Unit at King Abdulaziz University, Jeddah, SA (reference number: #89-21). All clinical data retrieved were anonymized, ensuring patient confidentiality.

We used 2 risk assessment scores in the study (Caprini and Padua). Both are used as prospective risk assessment tools for VTE.

The Caprini score was prospectively collected from the VTE risk assessment score calculated on patient admission to any of the hospital departments, whereas the Padua score was retrospectively calculated after reviewing the patient's history and medical records. The following components of the Padua score were collected: active malignancy, previous history of VTE, reduced mobility, heart failure, acute myocardial infarction or ischemic stroke, and active infection. The VTE risk assessment scores were calculated from the collected individual VTE risk factors for each hospitalized patient at KAUH, Jeddah, SA. Patients were then placed into risk categories for VTE for each score: Caprini low risk (0-1 points), moderate risk (2 points), high risk

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(3-4 points), and highest risk (>4 points); Padua low risk (<4 points) and high risk (≥4 points).

Hospitalized patients were divided into VTE risk categories as determined by the Caprini score on admission. Those with moderate to high risk underwent Doppler ultrasonography (unilateral or bilateral), CT pulmonary angiography, or both on the basis of clinical suspicion and presentation and were then divided into groups according to the study findings.

Our primary outcome was image-confirmed hospital-associated VTE, including PE at various lung sites and proximal upper or proximal lower extremity DVT. Patients were assessed on the basis of clinical suspicion and association with the VTE calculated risk of Caprini and Padua scores. The predictivity and accuracy of each tool was also assessed.

Statistical analysis. All data were analyzed by using The Statistical Package for the Social Sciences, version 25.0 for Windows (IBM Corp., Armonk, NY, USA). All qualitative variables are presented as frequency and percentages (%). The Chi-square test was applied to determine significant associations between the DVT and non-DVT groups and the PE and non-PE groups across different variables. An independent sample t-test was applied to determine significant differences in age between the DVT and non-DVT groups and the PE and non-PE groups. A 2×2 table was generated to calculate the sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and diagnostic accuracy of the Caprini and Padua scores. Kappa statistics were applied. A *p*-value of <0.05 was considered significant.

Results. During the study period from January to December 2019, a total of 478 hospitalized patients met the inclusion criteria. The baseline characteristics of the included patients are shown in Tables 1 & 2. The median Caprini score was 3 with a range from 0-9. One third of the population had a Caprini risk score of 5 and above (n=147, 30.69%). Of the 478 patients identified, 28 were diagnosed with DVT, whereas DVT was excluded in the remaining 450. The mean age across both groups was not significantly different (57.32±21.7 vs. 52.35±19.4, p=0.194). In the DVT group, a larger proportion of patients (39.3%) were >70 years old compared with those in the non-DVT group, and this difference was statistically significant (p=0.025). Male patients were more prevalent in the DVT group than in the non-DVT group (53.6% vs. 46.9%, p=0.56). A high Caprini score was more prevalent in the DVT group than in the non-DVT group (50.0% vs. 29.6%, p=0.023). Previous VTE, reduced mobility, acute infection, and a low vs. high Caprini score were considered significant (p<0.05; Table 1).

Of the 478 patients identified, 50 were diagnosed with PE, whereas PE was excluded in the remaining 428. The mean age was significantly different between groups (46.36±20.3 vs. 53.38±19.4, p=0.016). Male patients were more prevalent in the PE group than in the non-PE group (60.0% vs. 45.8%, p=0.057). Acute infection, low vs. high Caprini score, and low vs. high Padua score were considered significant (p<0.05; Table 2).

A comparison of the diagnostic accuracy of the Caprini and Padua scores is shown in Table 3. The

Table 1 - Characteristics of deep vein thrombosis and non-deep vein thrombosis patients.

Characteristics	DVT (n=28)	Non-DVT (n=450)	*P*-values
Age (mean±SD)	57.32±21.7	52.35±19.4	0.194*
Older age >70	11 (39.3)	95 (21.1)	0.025†‡
Obesity	8 (28.6)	127 (28.6)	0.98†
Gender			
Male	15 (53.6)	211 (46.9)	0.56†
Female	13 (46.4)	239 (53.1)	
Active cancer	6 (21.4)	122 (27.1)	0.510†
Previous VTE	8 (28.6)	28 (6.2)	0.000†‡
Reduced mobility	16 (57.1)	167 (37.1)	0.04†‡
Heart failure	4 (14.3)	88 (19.6)	0.493†
Acute MI/ischemic stroke	2 (7.1)	57 (12.7)	0.389†
Acute infection	7 (25.0)	198 (44.0)	0.049†‡
Caprini score classification (low vs. high)	14 (50.0) vs. 14 (50.0)	317 (70.4) vs. 133 (29.6)	0.023†‡
Padua score classification (low vs. high)	10 (35.7) vs. 18 (64.3)	211 (46.9) vs. 239 (53.1)	0.250†

Values are presented as numbers and precentages or mean ± standard deviation (SD). *Independent sample t test. †Chi-square test. ‡Significant *p*-value of <0.05. DVT: deep vein thrombosis, VTE: venous thromboembolism, MI: myocardial infarction, vs.: versus

sensitivity (95.98% vs. 64.29%), specificity (92.14% vs. 46.89%), PPV (93.0% vs. 7.00%), and accuracy (94.14% vs. 47.91%) of the Caprini score were higher than those of the Padua score. The overall predictive accuracy of the Caprini score was more accurate and higher than that of the Padua score (Table 3). Regarding the diagnostic accuracy of the Caprini vs. Padua scores across different departments, we found that the Caprini score showed higher sensitivity in the Critical Care department than the Padua score did (93.33% vs. 90.45%%; Table 4).

Discussion. The Caprini and Padua RAMs are valuable tools for identifying patients at risk of VTE in different clinical settings. Whereas the Caprini model is more widely used in surgical patients, the Padua model caters specifically to medical patients.[20] Both models have their strengths and limitations, and their selection should be based on patient population and clinical context. Despite a large proportion of hospitalized patients appearing to be at high risk for the consequences of VTE, thromboprophylaxis is still not adequately carried out.[21-25] Thus, which preventive measure for VTE is most reliable and effective has emerged as a critical open question. In this study, both DVT and non-DVT patients were assessed with Caprini and Padua RAMs, as recommended by the American College of Chest Physicians. Caprini RAM outperformed Padua RAM in terms of sensitivity, PPV, and NPV, in consistency with the results of earlier investigations, which reported that the Caprini RAM was more accurate than the Padua RAM at making predictions.[20,26,27] In the present study, risk factors such as older age (age >70 years), previous VTE, reduced mobility, acute infection, and low or high Caprini score classification were significantly higher in VTE patients than in non-VTE patients. This result is in accordance with the findings of Kupelian et al[28] and Alabdulkarim et al.[29] Therefore, it appears that the additional evaluation parameters in the Caprini RAM could account for its greater accuracy compared with

Table 2 - Characteristics of pulmonary embolism and non-pulmonary embolism patients.

Characteristics	PE (n=50)	Non-PE (n=428)	*P*-values
Age (mean±SD)	46.36±20.3	53.38±19.4	0.016*‡
Elder age >70	8 (16.0)	95 (22.1)	0.267†
Obesity	13 (26.0)	122 (28.5)	0.71†
Gender			
Male	30 (60.0)	196 (45.8)	0.057†
Female	20 (40.0)	232 (54.2)	
Active cancer	14 (28.0)	114 (26.6)	0.84†
Previous VTE	7 (14.0)	29 (6.8)	0.067†
Reduced mobility	25 (50.0)	158 (36.9)	0.072†
Heart failure	5 (10.0)	87 (20.3)	0.08†
Acute MI/ischemic stroke	6 (12.0)	53 (12.9)	0.938†
Acute infection	28 (56.0)	177 (41.4)	0.048†‡
Caprini score classification (low vs. high)	25 (50.0) vs. 25 (50.0)	306 (71.5) vs. 122 (28.5)	0.008†‡
Padua score classification (low vs. high)	15 (30.0) vs. 35 (70.0)	206 (48.1) vs. 222 (51.9)	0.015†‡

Values are presented as numbers and precentages or mean ± standard deviation (SD).
*Independent sample t test. †Chi-square test. ‡Significant *p*-value of <0.05. PE: pulmonary embolism, VTE: venous thromboembolism, MI: myocardial infarction, vs.: versus

Table 3 - Overall comparison of diagnostic accuracy of Caprini and Padua scores.

Diagnostic accuracy	Caprini score	Padua score
Sensitivity	96.0%	64.3%
Specificity	92.1%	46.9%
Positive predictive value	93.0%	7.0%
Negative predictive value	95.5%	95.5%
Accuracy	94.1%	47.9%
Kappa	0.0%*	0.0%*

*Significant.

Table 4 - Comparison of diagnostic accuracy of Caprini and Padua scores by hospital departments.

Departments	Caprini scores		Padua scores	
	Sensitivity	Specificity	Sensitivity	Specificity
Critical Care	21.1%	93.3%	12.4%	90.4%
Medical	42.2%	40.3%	53.7%	45.0%
Gynecology and Obstetrics	8.8%	87.3%	9.3%	86.0%
Surgical	27.9%	79.4%	24.5%	79.1%

the Padua model, and the low sensitivity of the Padua RAM for VTE could be related to the fact that many patients with multiple high risks were undervalued in that model. In addition, we found that the Critical Care, Gynecology, and Obstetrics departments benefited from using the Caprini RAM, even though it was typically recommended for the evaluation of patients in surgical departments.[27,30,31]

The Caprini RAM has demonstrated several advantages in identifying VTE risk.[32] Numerous studies have provided evidence supporting its effectiveness in surgical patients. For instance, a study by Geerts et al[33] involving over 15,000 surgical patients found that the Caprini score was significantly associated with the occurrence of postoperative VTE. In another study, Obi et al[34] evaluated the Caprini RAM in 3955 patients undergoing general, orthopedic, transplant, or urology surgery. The results showed that patients with higher Caprini scores had a greater risk of postoperative VTE. In addition, in their systematic review, Mrad et al[35] reported that the Caprini RAM is more predictive of postoperative VTE incidents in high-risk plastic surgery patients than is the American Society of Anesthesiologists grading system. These findings highlight the advantages of the Caprini RAM in effectively identifying patients at risk of VTE, thereby allowing for timely interventions and preventive measures to mitigate this serious complication.

Given the limited number of direct comparative studies that specifically focus on PPV between the Caprini and Padua models, it is challenging to make definitive conclusions regarding their performance differences. The PPV of a RAM reflects the proportion of patients classified as high risk who actually develop VTE. Although they do not directly compare PPVs, individual studies assessing the performance of the Caprini and Padua models provide some insights. For example, Wen et al[36] evaluated the Padua model in hospitalized medical patients and reported a high sensitivity of 91.3%. This finding suggests that the Padua model has a high ability to identify true positives, but its PPV would depend on the prevalence of VTE in the specific population studied. Similarly, studies that evaluate the Caprini model have demonstrated its ability to predict VTE risk, but specific data on PPV are limited. For instance, Obi et al[34] assessed the Caprini model in surgical patients and found that higher Caprini scores were associated with an increased risk of postoperative VTE. However, direct PPV comparisons with the Padua model were not reported.

To be successful and cost-efficient, a RAM should be able to reliably identify patients at risk, increase the rates of clinical events and preventative measures, and have external validity from clinical studies. Before beginning thromboprophylaxis, a patient must be determined to be at risk for VTE. Therefore, the RAM must be implemented in order to prevent the development of VTE.[37] The Caprini RAM is widely used in various countries for assessing VTE risk, including in surgical patients.[20] Although specific studies that evaluate the Caprini model's utility in SA are lacking, the fundamental risk factors (for example, age, comorbidities, and surgery type) remain relevant in this context. It is essential to consider the prevalence and impact of risk factors specific to the Saudi Arabian population, such as genetic predispositions, lifestyle factors, and cultural practices, which may influence VTE risk.

Study limitations. The Caprini model was prospectively collected at the time of admission by using information from the history of patients and reviewing the records. However, Padua scores were collected retrospectively at the time of the study. Hence, the choice of RAM and treatment strategies may not have been randomly assigned, but instead influenced by various factors, including the patient's clinical condition, physician preference, or institutional guidelines. These factors can introduce bias and confound the results, potentially affecting the comparison between the 2 RAMs. In addition, the data were collected from medical records, which may be subject to error, missing information, or inconsistent documentation. Inaccurate or incomplete data can affect the reliability and validity of the study results, potentially leading to

biased comparisons between the Caprini and Padua models. Moreover, both scores were calculated at a single point in time during the hospitalization which was on admission. Change in patients clinical status during hospitalization could have affected or changed the risk score, and that was not explored in this study given its retrospective nature. Prospective design with updated dynamic risk score assessment is needed to better assess the diagnostic accuracies of those tests. With regards to diagnostic accuracy across different departments, given the small number of events per each department, those results should be interpreted with caution and larger studies are needed to further explore this association. Prospective studies, with predefined protocols and systematic data collection, are better suited for evaluating the comparative effectiveness of RAMs.

In conclusion, the Caprini RAM demonstrated higher levels of sensitivity, specificity, and accuracy than the Padua RAM did and distinguished between low and high VTE risk in hospitalized patients. The application of the Caprini RAM could potentially improve the impact of VTE prophylaxis and reduce the risk of VTE in hospitalized patients. Therefore, integration of the Caprini RAM into the electronic medical records system should be considered to facilitate risk assessment. The degree of sensitivity and specificity depends on the department in which the Caprini score is used. As a result, generating a gold standard scoring system would directly help clinicians to detect patients at high risk of VTE, thus improving quality of life and reducing health care costs. Variations occur across different populations and availability of institutional resources, therefore, protocols should be tailored accordingly.

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