ORIGINAL ARTICLE

# Diagnostic Accuracy of Well's Score in Clinically Suspected Deep Venous Thrombosis

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## Abstract
The Wells scoring system for risk assessment of developing Deep Venous Thrombosis (DVT) is primarily designed to be used in the outpatient settings. We aimed to determine the validity, discrimination ability, and clinical utility of Wells scoring system in risk stratification of patients suspected of DVT in an inpatient setting in Saudi Arabia as compared to another outpatient population. All Patients who underwent lower limb Doppler ultrasound at King Abdulaziz University Hospital between January 2016 and July 2017 and were suspected to have DVT are included. A total of 1934 clinically-suspected DVT patients are analyzed (34.6% males and 65.4% females). 53.62% were outpatients and 31.8% were inpatients. Doppler ultrasound confirmed DVT in 304 patients. Incidence of DVT in outpatients was 5.9% for low probability; 8% for moderate probability; 18.5% for high probability, whereas the inpatients had an incidence of 4.1% for low probability; 8.4% for moderate probability; 15.7% for high probability. The negative predictive value of Wells score in outpatients is 94.1% and 95.9% for inpatients. Results of Well's score demonstrate an excellent discrimination ability in ruling out DVT in both the outpatient and inpatient settings.

## Keywords
Well's score; Well's criteria; Inpatient; Outpatient; DVT; Ultrasound

## Introduction

Deep venous thrombosis (DVT), a division of venous thromboembolism besides pulmonary embolism, has been estimated to have an incidence of 1 per 1000 population annually, worldwide[1]. That being said, the DVT cases in Saudi Arabia is recently reported to surpass that of the reported worldwide, with incidence rate reaching up to 15.7%[2]. As regards the inpatient setting, 8 million inpatients each year are defined as a high risk group for developing DVT with the potentiality of occurring complications, such as pulmonary embolism[3].

DVT can be definitively diagnosed through lower-extremity ultrasound scanning and its considered the gold standard, however, its use for scanning asymptomatic patients may not be the best option and is definitely not a cost-effective diagnostic approach to being with[4,5]. In the same context, DVT presenting signs and symptoms are non-specific and that would lead to an increase in unnecessary imaging[6,7]. In addition, other modalities are not primarily used for diagnosing DVT in the lower limb due to the ultrasound being less time and resource consuming. Therefore, a more practical approach is to develop a fast applicable system to determine the pretest probability of the patient for developing DVT[8].

Multiple tools are readily available, the mostly used and accepted tool is the Wells score system. The Wells score system is a scoring tool aimed at patients presenting in the outpatient setting which uses patient' relevant Hx and presentation to determine the pretest probability of the patient suffering a DVT and the best next step in management[7].

The Wells score system has been used for over a decade and has been validated in the outpatient setting and emergency departments[9-11]. However, while inpatients may present with various DVT risk profiles, occasionally higher risk than outpatient, with increased prevalence of morbidities and risk factors including ischemic heart diseases, asthma, atherosclerosis, acute infection, active cancer status, immobility, and surgical procedures in the last 12 weeks, the utilzation of Wells score for inpatient could be inapplicable.[12-14] Recent investigation of the validation of Wells score in an inpatient population has shown that Wells score system is of poor discrimination ability and is not sufficient in ruling out DVT[15]. Furthermore, patient's history and physical examination were not useful in directing physician suspicion towards a diagnosis of DVT in the ICU settings[16]. While laboratory tests, such as D-dimer might prove useful in patients with suspected DVT, it will not add much in the inpatient setting due to patient already high D-dimer caused by another condition[17-19]. Although a few previous studies had proven well's score is a good tool to be used in the inpatient setting, all of them were suboptimal[20-22].

Therefore, we conducted this current study in order to examine the validity of Wells scoring system in assessing the risk of a set of inpatients with suspected DVT and compare it to the results of an outpatient population in Saudi Arabia.

## Materials and Methods

We are conducting a retrospective chart review study. Patients who were clinically suspected of having DVT and had furtherly lower limb Doppler ultrasound at King Abdulaziz University Hospital, Saudi Arabia, were considered eligible for participation in our study. All patients who had the Doppler study between January 2016 and July 2017 were investigated for eligibility of inclusion into the study. A total of 2203 charts during the study period were retrieved from King Abdulaziz Hospital archive system (Sectra, Phoenix). Patients with prior diagnosis of DVT using any mean or modalities other than lower limb Doppler ultrasound were excluded. Approval of the study protocol was granted from the Institutional Review Board (IRB) of the research ethics committee at King Abdul-Aziz University faculty of medicine.

The probability of developing DVT in patients who are clinically-suspected of having DVT could be predicted by the Wells scoring system[11]. The score of each individual patient was estimated blindly by a third party (critical care fellow) through a review of the clinical symptoms and patients' history in each patient's charts in the archive system and through the notes of the medical staff who were in charge of those patients. We give each patient an overall score based on the chart review and eventually categorize them into one of three categories: low, moderate, and high probability of developing DVT. Each probability category measures the relative frequency of DVT in both the inpatient and outpatient setting, separately. In addition, we calculate the sensitivity, specificity, and the negative and positive predictive values, with a cut-off point of 1, to determine the validity of Wells score system in predicting the probability of developing DVT in each setting (outpatient vs inpatient) separately. We are going to carry out the receiver operating characteristic (ROC) curve analysis, in addition to using the area under the curve (AUC) as a marker to measure the performance of the Wells score in both the inpatient and outpatient settings.

For statistical analysis, relevant data were retrieved from charts, entered into a standardized form of Excel sheet, coded, and then analyzed the data utilizing the Statistical Package for Social Sciences (IBM SPSS version. 22). Retrieved data was completely anonymized, only authors had access to the data set, it included: demographic data (age, gender) and the setting of the behold tests (inpatient or outpatient); medical data (cancer history in the past six months, surgical history in the past month, immobilization history more than three days, previous DVT, history of pulmonary embolism (PE), symptoms suggestive of DVT, Duplex scan findings regarding the presence or absence of DVT, and eventually the acute or chronic state of DVT through CT-Pulmonary angiogram results.

The characteristics of the variables were defined by a simple descriptive statistic for categorical and nominal variables. The mean and standard deviations are used to present continuous variables. The relationship between categorical variables is established using the Chi-square test. A conventional p-value of <.05 is considered the cut-off point for statistical significance. With regards to the Wells scoring system, data are categorized into three groups (low probability, moderate probability, and high probability) and analyzed using the IBM SPSS (Version 22). Parametric data are expressed as mean and standard deviations. the non-parametric data are expressed as numbers (percentages). For qualitative data we used the Chi-square as a test of significance for comparison, with P values of less than 0.05 considered to be significance.

The discrimination accuracy of Wells score in both settings, is measured using the area under the receiver operating characteristic curve, in which the sensitivity (true positive rates) are plotted against the specificity (false positive rates)[16].

## Results

Out of 2203 primarily eligible participants, 1934 patients are included in the final analysis. The characteristics with clinically suspected of the population is summarized in (Table 1). Sixty five percent are female participants while males constituted 34.6% of the study population. The ages of our population were from 18 years to 100 years of age with a mean age of 53.6 (17.2). Most of our study participants (53.62%) were outpatients, while 31.8% were inpatients. Saudis accounted for nearly half of the population with a rate of 49.9%. From a co-morbidity distribution perspective, Diabetes Mellitus (DM) is the most common encountered disorder in our population followed by Hypertension and other medical disorders with a percentage of 40%, 39.3%, and 35.1%, respectively. Active cancer status (within the last 6 months) was positive for 9.05% of the total studies population. A full description of comorbidity distribution in our population is provided in Figure 1.

A minority of our patients (19.34%) had major surgery in the previous four weeks, while 12.87% of the total population were recently bedridden (within the last three days). Pulmonary Embolism (PE) was diagnosed in 3.36% of the whole sample. A total of 304 patients (15.72%) had a confirmed diagnosis of DVT through Doppler ultrasound. Additionally, serum D-dimer level was elevated in a total of 375 patients accounting for 25.08% of the whole population. In the same context, swelling of the lower limbs was the most common presentation of DVT followed by pain and tenderness, varicose veins, others, difference in size between lower limbs, and hotness with redness, respectively. The frequency of the presenting symptoms of DVT are summarized in Figure 2.

For the purposes of investigating the correlation between the incidence of DVT and age, we categorized age into three different age groups: young (13-30 years), middle (31-50 years), and senior (51-70 years). Upon investigating the correlation between DVT and patient demographics, we found that the young age group had significantly higher incidence of DVT compared to the middle and senior age groups (30.7%, 25.1%, 7.8%, P-value < 0.001), respectively. Additionally, females were significantly more likely to develop DVT as compared to male patients (19.2% vs 9.1%, P-value < 0.001). However, nationality of included participants was not significantly associated with the incidence of DVT (P-value = 0.844).

The association between developing DVT and other existing comorbidities such as hypertension, DM, ischemic heart diseases, sickle cell anemia, stroke, and other medical conditions was negative. None of the patients with the aforementioned comorbidities developed DVT during the time of assessment. Our analysis shows that non-bedridden patients are significantly more prone to develop DVT compared to bedridden ones with an incidence of 16.6% and 9.6% respectively (P-value = 0.005). On the other hand, no significant correlation between DVT and previous surgeries or orthopedic condition of the patients was noted with a P-value of 0.122 and 0.716, respectively.

The presenting symptoms of hotness and redness, varicosity of lower limb veins, and lower limb swelling were of significant association with the diagnosis of DVT (P-value < 0.001) (Table 2). Outpatients were

**Table 1.** **Characteristics of the study subjects**

| | | | Diagnosed DVT | | Total | P-value |
|---|---|---|---|---|---|---|
| | | | No | Yes | | |
| Age (mean ± SD) | 53.6 ± 17.2 | Young Age (13–30) | 147 | 65 | 212 | <.001 |
| | | Middle Age (31–50) | 454 | 152 | 606 | |
| | | Senior Age (>51) | 1029 | 87 | 1116 | |
| Gender (%) | 34.6 | Male | 608 | 61 | 669 | <.001 |
| | 65.4 | Female | 1021 | 243 | 1264 | |
| Nationality (%) | 49.9 | Saudi | 867 | 95 | 962 | .844 |
| | 50.1 | Non-Saudi | 868 | 98 | 966 | |
| DM | Yes | | 773 | 0 | 773 | <.001 |
| | No | | 857 | 304 | 1161 | |
| HTN | Yes | | 761 | 0 | 761 | <.001 |
| | No | | 869 | 304 | 1173 | |
| IHD | Yes | | 168 | 0 | 168 | <.001 |
| | No | | 1462 | 304 | 1766 | |
| Dyslipidemia | Yes | | 185 | 0 | 185 | <.001 |
| | No | | 1445 | 304 | 1749 | |
| SCA | Yes | | 44 | 0 | 44 | .004 |
| | No | | 1586 | 304 | 1890 | |
| Cancer | Yes | | 141 | 0 | 141 | <.001 |
| | No | | 1489 | 304 | 1793 | |
| Asthma | Yes | | 33 | 0 | 33 | <.001 |
| | No | | 1597 | 304 | 1934 | |
| Stroke | Yes | | 90 | 0 | 90 | <.001 |
| | No | | 1540 | 304 | 1844 | |
| Arthritis | Yes | | 31 | 0 | 31 | .015 |
| | No | | 1599 | 304 | 1934 | |
| Hypothyroid | Yes | | 110 | 0 | 110 | <.001 |
| | No | | 1520 | 304 | 1824 | |
| ESRD | Yes | | 82 | 0 | 82 | <.001 |
| | No | | 1548 | 304 | 1852 | |
| Free | Yes | | 1630 | 0 | 1630 | <.001 |
| | No | | 0 | 304 | 304 | |
| Bed ridden | Yes | | 225 | 24 | 249 | .005 |
| | No | | 1405 | 280 | 1685 | |
| Previous surgery | Yes | | 324 | 49 | 373 | .122 |
| | No | | 1301 | 255 | 1556 | |
| Orthopedic Condition | Yes | | 197 | 39 | 236 | .716 |
| | No | | 1433 | 265 | 1698 | |

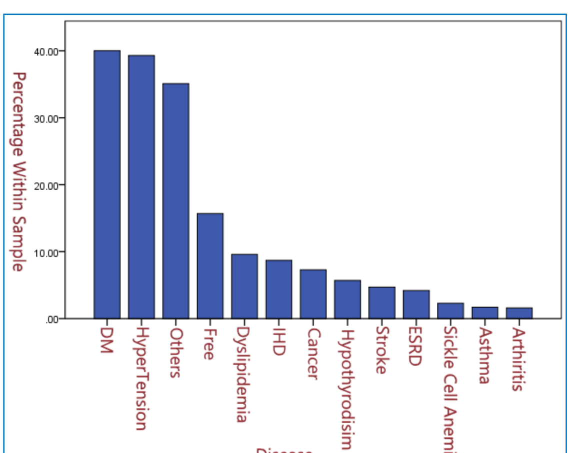


**Figure 1.** **Distribution of encountered diseases in our population.**

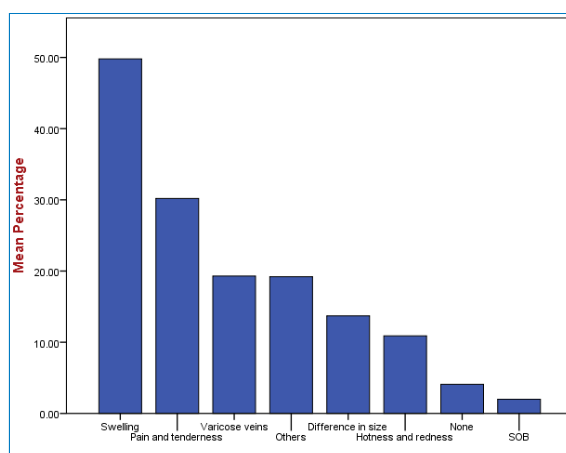


**Figure 2.** **Presenting symptoms in patients diagnosed with DVT.**

**Table 2.** The correlation between DVT and presenting symptoms

| | | Diagnosed DVT | | Total | p-value |
|---|---|---|---|---|---|
| | | No | Yes | | |
| Hotness and redness | Yes | 194 | 14 | 208 | <.001 |
| | No | 1,413 | 290 | 1,703 | |
| Difference in size | Yes | 228 | 33 | 261 | .121 |
| | No | 1,379 | 279 | 1,650 | |
| Varicose veins | Yes | 236 | 133 | 369 | <.001 |
| | No | 1,371 | 171 | 1,542 | |
| Swelling | Yes | 862 | 90 | 952 | <.001 |
| | No | 745 | 214 | 959 | |
| SOB | Yes | 30 | 9 | 39 | .216 |
| | No | 1,577 | 299 | 1,872 | |
| Pain and tenderness | Yes | 496 | 81 | 577 | .142 |
| | No | 1,111 | 223 | 1,334 | |
| Others | Yes | 324 | 43 | 367 | .015 |
| | No | 1,283 | 261 | 1,544 | |
| None | Yes | 68 | 10 | 78 | .447 |
| | No | 1,539 | 294 | 1,833 | |

**Table 3.** The correlation between patients' status and history with the incidence of DVT

| | | Diagnosed DVT | | Total | p-value |
|---|---|---|---|---|---|
| | | No | Yes | | |
| Patient status | N\A | 233 | 49 | 282 | <.001 |
| | Outpatient | 842 | 195 | 1,037 | |
| | Inpatient | 555 | 60 | 615 | |
| Previous DVT | Yes | 197 | 18 | 215 | .002 |
| | No | 1,433 | 286 | 1,719 | |
| Previous PE | Yes | 80 | 11 | 91 | .325 |
| | No | 1,545 | 295 | 1,838 | |

**Table 4.** Wells scoring system for predicting deep venous thrombosis (DVT)[a]

| Clinical Characteristic | Score |
|---|---|
| Active cancer (patient either receiving treatment for cancer within the previous 6 months or currently receiving palliative treatment) | 1 |
| Paralysis, paresis, or recent cast immobilization of the lower extremities | 1 |
| Recently bedridden for ≥ 3 days, or major surgery within the previous 12 weeks requiring general or regional anesthesia | 1 |
| Localized tenderness along the distribution of the deep venous system | 1 |
| Entire leg swelling | 1 |
| Calf swelling at least 3 cm larger than that on the asymptomatic side (measured 10 cm below tibial tuberosity) | 1 |
| Pitting edema confined to the symptomatic leg | 1 |
| Collateral superficial veins (non-varicose) | 1 |
| Previously documented deep vein thrombosis | 1 |
| Alternative diagnosis at least as likely as deep vein thrombosis | -2 |

more likely to have a diagnosis of DVT as compared to inpatient ones (18.8% vs 9.8%, P-value < 0.001). Noteworthy, patients who had no previous DVT were significantly more likely to develop DVT than those with a positive history of a previous DVT (16.6% vs 8.4%, P-value = 0.002). However, previous history of PE is not significantly associated with the incidence of DVT (P-value = 0.325) (Table 3). Surprisingly, patients with elevated D-dimer levels are less likely to have a diagnosis of DVT when compared to patients with elevated levels (9.1% vs 18.1%, P-value < 0.001).

We determine patient's probability of developing DVT utilizing the Wells criteria (Table 4). Each individual patient was assigned a score according to the criteria and scores were subsequently classified into three categories: low probability: -2 - 0 points; moderate probability: 1 - 2 points; finally 3 - 8 points are counted as high probability. Classified according to the aforementioned categories, the incidence is found to be 5.9% and 4.1% in low probability according to outpatient and inpatient setting, respectively. As for the moderate probability, DVT incidence was 8% and 8.4%

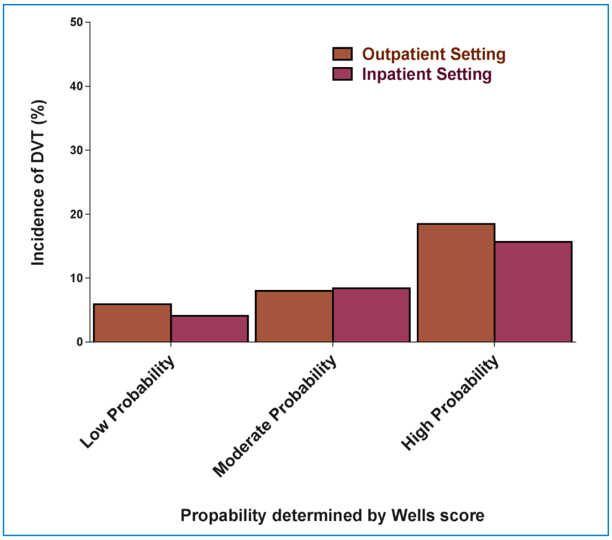


**Figure 3.** **Incidence of DVT by probability estimation on the Wells scoring system: low, moderate, and high (Incidence increases with increasing risk).**

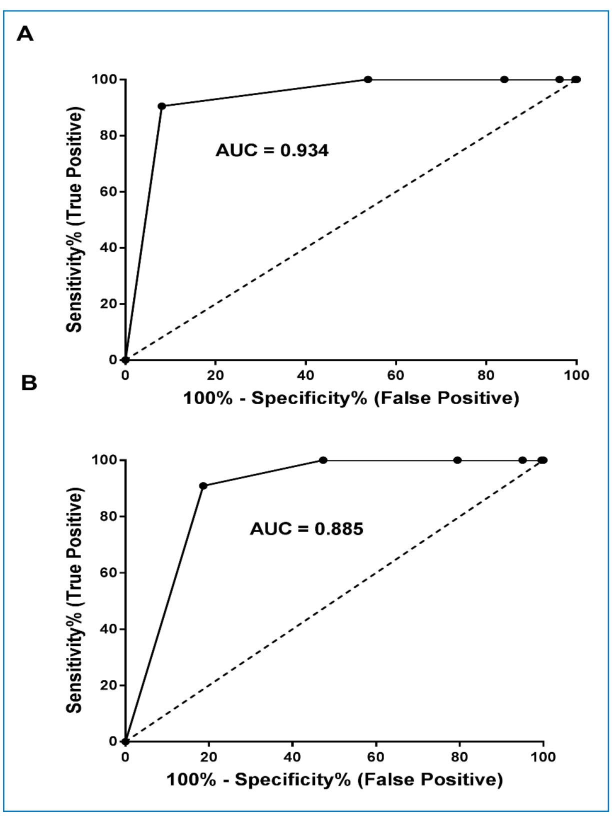


**Figure 4.** **Receiver operating characteristic (ROC) curve demonstrating the performance of Wells score in predicting likelihood of DVT at outpatient setting; B) Receiver operating characteristic (ROC) curve demonstrating the performance of Wells score in predicting likelihood of DVT at inpatient setting).**

in the outpatient and inpatient, respectively. While in the high probability, DVT's incidence was 18.5% and 15.7% for the outpatient and inpatient, respectively (Figure 3). Furthermore, the percentage of patients of low, moderate and high probability with DVT in the outpatient setting was 3.8, 8.3 and 21.2% of their respective population. While in the inpatient setting low, moderate and high probability patients with DVT were 4.5, 9.7 and 18.2% of their respective population as seen in Figures 4 and 5.

In terms of performance of the Wells score in the outpatient and inpatient settings for detecting the probability of DVT, the Wells score has the ability to rule out the presence of DVT in outpatients with a sensitivity of 100% (95% CI: 99.6%-100%) in addition to a negative predictive value (NPV) of 94.1% (95% CI: 86.6%-98%), which supports the existing literature on the validity of Wells score in the outpatient setting. On the other hand, the Wells score in the inpatient setting showed lower sensitivity and specificity (46.2%, 52.7%) as compared to the outpatient, it has been shown to be a very good negative test of DVT with a NPV of 95.9% (Table 5).

The estimation of the efficacy of risk stratification according to the Wells scoring system is conducted

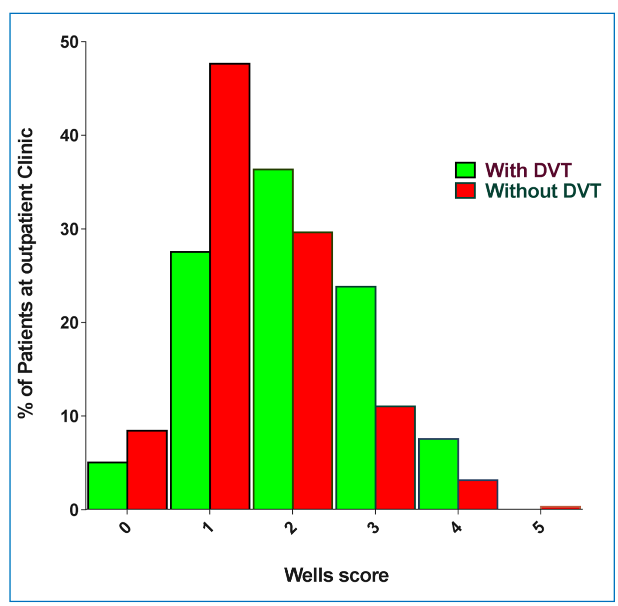


**Figure 5.** **Distribution of Wells scores in patients of outpatient setting with and without DVT (Median Wells score of patients with DVT was significantly higher than the median Wells score of patients without DVT (2 vs. 1, p < 0.0001)).**

**Table 5. Statistical measures of performance of Wells score in predicting DVT in patients with cut off scores of one**

| Parameter | Outpatient Setting | | Inpatient Setting | |
|---|---|---|---|---|
| | Value | 95 % CI | Value | 95 % CI |
| Sensitivity | 100% | 99.6% to 100% | 46.20% | 42.8% to 49.6% |
| Specificity | 100% | 99.3% to 100% | 52.70% | 48.3% to 57% |
| PPV | 9.80% | 7.9%-12% | 10.30% | 7.7%-13.4% |
| NPV | 94.10% | 86.6%-98% | 95.90% | 90.6%-98.6% |

through analyzing the receiver operating characteristics (ROC) curve analysis in order to for our analysis to reveal the accuracy of Wells score to identify subjects with high likelihood of developing DVT in both the outpatient and inpatient setting; the area under curve (AUC) is 0.934 and 0.885 for each setting, respectively (Figure 6).

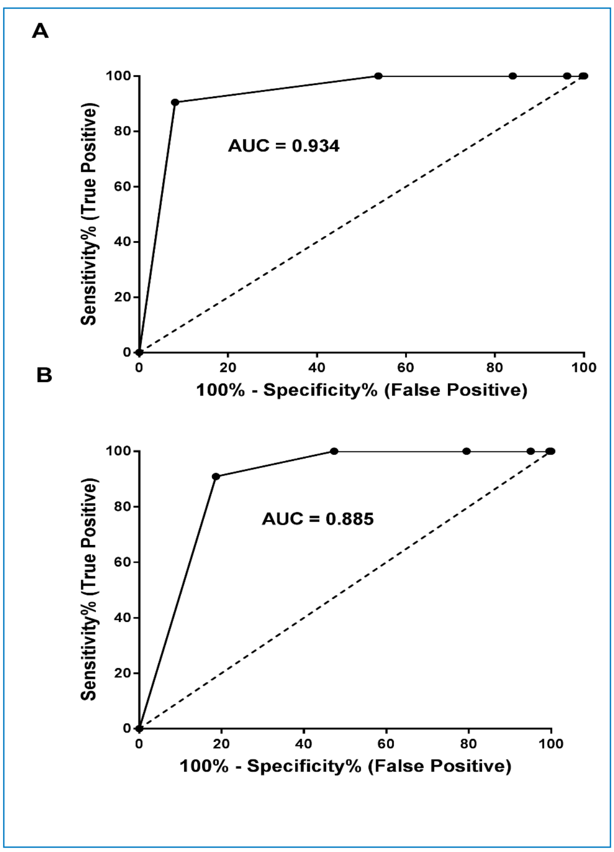


**Figure 6. Receiver operating characteristic (ROC) curve demonstrating the performance of Wells score in predicting likelihood of DVT at outpatient setting; B) Receiver operating characteristic (ROC) curve demonstrating the performance of Wells score in predicting likelihood of DVT at inpatient setting.**

## Discussion

The Wells scoring system has been clinically validated in the outpatient setting and used over a decade for risk stratification of patients at risk of developing DVT, however, this efficacy in the inpatient setting has not yet been verified[17,18]. In our knowledge, this is the first and largest study conducted, to date, in order to compare the clinical utility and validity of Wells scoring system for patients are suspected for DVT in both the inpatient and outpatient settings in Saudi Arabia.

Upon comparing the differences in incidence of DVT in the inpatient to the outpatient setting with regard to the different pretest probability groups, our analysis revealed that Wells score was able to identify more DVT patients of low and high probability in the outpatient setting as compared to the inpatient (5.9% vs 4.1%; 18.5% vs 15.7%), respectively. However, the moderate probability group demonstrated a higher incidence of DVT in the inpatient as compared to the outpatient setting (8.4% vs 8%), respectively. That being said, the differences in the incidence of DVT across all probability groups in both the inpatient and outpatient in our study were of narrow range as compared to the much broader range for outpatients in the study of Wells et al.[11].

Upon estimating the validity and utility of Wells score in the inpatient and outpatient setting, separately, we found that Wells score system in the outpatient setting has a sensitivity and specificity of 100% and a NPV of 94.1%, revealing a the very good ability of Wells score by ruling out the diagnosis of DVT in patients with a pretest probability score of less than 1, which is supported in the literature[11]. alternatively , even though the usage of Wells score in the inpatient setting has shown poorer sensitivity and specificity in comparison with the outpatient, our analysis revealed very high NPV for Wells score system in the inpatient of 95.9%, higher than that of the outpatient. In addition to that, our analysis revealed that in the inpatient setting Wells score had a very high discrimination ability of risk of DVT (AUC = 0.885), slightly lower than that of the outpatient setting (AUC = 0.934). The aforementioned findings of our study indicate that Wells score risk stratification can efficiently be used in ruling out patients with suspected DVT of a score less than 1 in the inpatient setting with very good discrimination ability and can also be used in influence treatment and management decisions in clinical practice, reassuring provider treatment stewardship to do no harm. Our results are the first in the literature to support the clinical utility of Wells score in the inpatient setting, while many other studies have reported contradictory results, where Wells score was shown to have very poor discrimination ability of the risk of DVT (AUC = 0.60) in the inpatient setting,[15] (AUC = 0.56) for inpatients,[12] and (AUC= 0.59) in the intensive care unit[16].

In 2015, Silveira et al.[15] had carried out the largest study to determine the utility of Wells score in risk stratification of DVT in the inpatient setting, and they concluded that Wells score was insufficient in ruling out DVT or influence their hospital course. The discrepancy between both our findings could be related to the background morbidities of the recruited participants. The majority of their patients (more than two thirds of the total sample) underwent a major surgical procedure within the last 12 weeks prior to assessment or were recently bedridden, and more than one third had an active cancer status. These factors could be the main contributors to such discrepancy, as previously stated in the literature that inpatients have increase of prevalence of recent immobilization by 6 folds, a higher incidence of active cancer by 3 folds[11]. On the other hand, the presenting comorbidities in our population were very minimal compared to that of Silveira et al.,[15] where only 19.34% had previous surgery (within the last 4 weeks); 12.87% were bedridden (within the past 3 days); 9.05% had active cancer status (within the past 6 months). Moreover, none of the patients diagnosed with DVT had asthma, arthritis, diabetes mellitus, hypertension, ischemic heart disease, or stroke.

Going in line with our findings, the analysis of Ambid Lacombe et al. revealed areas under the ROC curve of 0.92 to 0.96 for DVT diagnosis in 217 in patients with suspected DVT"[20]. The excellent discrimination capability that their analysis has shown could be related to the pretest probability conducted by one vascular surgeon compared to a variable set of vascular surgeons, as in the case of Engelberger et al. study[12]. More recently, the Wells score has been redeemed useful by a meta-analysis in the emergency department, primary care, and outpatient settings as a pretest probability predictor, excluding patients with active cancer status. However, the inpatient setting was not assessed in that meta-analysis[9]. On the other hand, two previous investigations reported good performance of the Wells score in the inpatient setting[21,22]. However, the sample size of those two studies were small and they were conducted more than 10 years ago. Herein, we report the findings of a current analysis of a much larger sample size which supports the excellent discrimination of Wells scoring system in ruling out patients with suspected DVT in an inpatient setting in Saudi Arabia based.

Several limitations are present to the current validation analysis. The accuracy of Wells score system may depend on the accuracy of the retrieved data, so any inaccurate data would have its substantial effect on the overall result and utility of Wells score system. Also, the validation of the Wells score system in our study is retrospective and a prospective investigation is required in order to support our findings and establish the efficacy of Wells scoring system in the inpatient setting.

## Conclusion

In conclusion, the well's scoring system has an excellent discrimination ability in ruling out DVT in suspected patients within the inpatient setting as in the outpatient setting.

Further prospective analyses are required in order to reach a definitive decision about its clinical utility and its discrimination ability in ruling out DVT within the inpatient setting.

## Conflict of Interest

The authors declared that there is no conflict of interest that is related to this study and this article.

## Disclosure

The authors did not receive any form of commercial support, either in the form of compensation or financial assistance, for this case report. The authors have no financial interest in any of the products, devices, or drugs mentioned in this article.

## Ethical Approval

Initial ethical approval was obtained 2018-02-11(25-5-1439) with a reference number of 406-17. After initial data collection was done, the authors recognized further use of the data collected, and applied for a secondary use of data for secondary research while changing some of the authors of the initial ethical approval/primary research. All authors of the initial research have agreed to the use of their data for the secondary research.

## Author's Contributions

Dr. Khafaji conceived the research question and prepared the design of the study. Dr. Marghalani, Dr. Alghamdi, Dr. Alsulami were responsible for data collection. Dr. Marghalani and Dr. Alghamdi interpreted the data and wrote the initial draft with the help of both Dr. Khafaji and Dr. Asaad. All authors contributed to the finished manuscript. The final manuscript has been critically reviewed by all authors, with responsiblity for the content and similarity index of the manuscript.

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