



Research article

Comparison of risk assessments for venous thromboembolism during the puerperium

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ABSTRACT

Objective: To compare the predictive value of different risk assessment methods for puerperium venous thromboembolism (VTE).

Methods: This study included 55 women with and 165 women without puerperal VTE. Using the cases, 11 assessment methods were compared.

Results: The area under the curve (AUC) value of the 11 assessments was highest for the modified Caprini risk assessment model for pregnancy (a modified risk scoring method from Caprini, AUC = 0.805). Pairwise comparison of the AUC values of the 11 assessment methods indicated no significant difference among the five methods with AUC values > 0.7. Among them, the modified Caprini, the risk scoring method recommended by the Swedish Guidelines (Swedish method), and the risk scoring method recommended by the Shanghai consensus (Shanghai method) performed better than the other six methods with AUC values < 0.7 (P < 0.05). The sensitivities of the five methods for predicting a high risk of VTE were 69.09–94.55% and the specificities were 25.45–77.58%. The sensitivity of the modified Caprini was higher than those of the risk management method from the Chinese consensus (Chinese consensus method), Royal College of Obstetricians and Gynaecologists risk assessment scale (RCOG), and Swedish method (P < 0.05), but the specificity was only 25.45%. No significant difference in sensitivity was detected among the Swedish, Shanghai, RCOG, and Chinese consensus methods, whereas the specificity of the Swedish method was higher than that of the Shanghai, RCOG, and Chinese consensus methods. **Conclusion:** The predictive value of different risk assessment methods for puerperium VTE varies greatly. Considering the sensitivity and specificity, the Swedish method may have better clinical application value among the 11 methods.

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1. Introduction

Venous thromboembolism (VTE) includes deep vein thrombosis (DVT) and pulmonary embolism (PE). The risk of VTE in pregnant women is 4–5 times that in the general population, or about 1.2‰, and is one of the most significant causes of death during pregnancy and the postpartum period [1]. Early prevention of VTE is important to reduce maternal mortality related to thrombosis. Many risk factors are less prevalent in pregnant and postpartum women than in non-pregnant women, and pregnancy-specific risk factors such as preeclampsia that does not resolve immediately after delivery, placenta previa, multiple pregnancies, and preterm birth are not included in the common scale. Combined with the above factors, various VTE risk assessment methods suitable for the puerperium have been proposed [2,3]. However, many were developed based on an expert consensus, and there is currently no recognized best risk assessment method. This study evaluated and compared the predictive value of existing VTE risk assessment methods during the puerperium.

2. Material and methods

Women with puerperal VTE admitted to hospital were collected as the case group from January 2015 to December 2021. Women admitted to the hospital during the same period without puerperal VTE were used as the control group (1 : 3). The informed consent was obtained from each participant. This study was approved by the Medical Ethics Committee of the Xiangya Hospital Central South University (202110191).

The case group met the following inclusion criteria: VTE occurred within 42 days after delivery; DVT was diagnosed by ultrasound, computed tomography, venous angiography, or magnetic resonance angiography; PE was confirmed by computed tomography pulmonary angiography or a pulmonary ventilation/perfusion scan. The exclusion criteria were DVT and PE suspicious and undiagnosed; patients with only a superficial venous thrombosis, such as great saphenous vein/small saphenous vein thrombosis; patients with VTE during pregnancy; and incomplete clinical data that could not be supplemented by followup.

The search terms pregnancy, postpartum, puerperium, puerperal, thrombosis, thromboembolism, embolism, PE, VTE, scoring system, risk score, risk stratification, and risk assessment were used to systematically search the PubMed, Embase, and China national knowledge infrastructure (CNKI) databases. Eleven assessment methods were obtained, including the risk scoring method recommended by the Swedish Guidelines (Swedish method) [4], the pregnancy health-care program (PHP) risk assessment scale [5], the royal college of obstetricians and gynaecologists (RCOG) risk assessment scale [6], the modified Caprini risk assessment scale for pregnancy (a modified risk scoring method from Caprini) [7,8], the modified Padua risk assessment scale for pregnancy [8,9], the risk assessment scale from Bretelle [10], the Shanghai risk assessment scale (Shanghai method) [11], the Chinese consensus assessment [12], the Queensland (QLD) risk assessment [1], the American college of obstetricians and gynecologists (ACOG) risk assessment [13], and the Society of Obstetricians and Gynaecologists of Canada (SOGC) risk assessment [14].

Data on perinatal women were obtained from the medical records. Relevant risk factors were obtained from the above guidelines and consensus. Eleven risk assessment methods were used to assess the risk of puerperium VTE on the day after delivery. According to the evaluation method, the recommended proportions of drug prophylaxis in the VTE and control groups were calculated.

Statistical analysis was performed using IBM SPSS 22.0 software. The measurement data were expressed as $\bar{x} \pm s$ (*t*-test), and the count data were expressed as *n* (chi-square test or Fisher's precision probability test). The other statistical methods are listed below tables. A receiver operating characteristic (ROC) curve was drawn based on the total score for the quantitative VTE risk assessment method. The ROC curve for the non-quantitative assessment method was drawn based on whether VTE occurred, and the area under

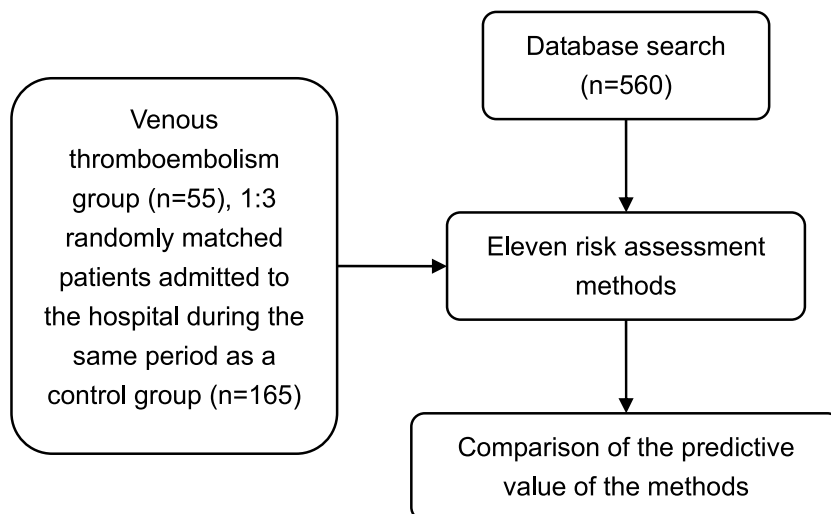


Fig. 1. Study flow chart.

the ROC curve was calculated. A *P*-value <0.05 was considered significant.

3. Results

Fifty-five cases of postpartum VTE were finally included. A total of 165 cases without puerperal VTE were included after 1:3 matching as the control group, and no VTE occurred within 42 days after delivery (Fig. 1). Table 1 shows general information on the two groups. The age of the VTE group was older than that of the control group, and the proportion of elderly pregnant women was higher. The main mode of delivery in the VTE group was cesarean section (92.7%), which was much higher than the control group (56.4%).

The items used in each risk assessment method were different, and we compared the predictive values of the different methods on our cases (Table 2). Pairwise comparison of the AUC values of the 11 assessment methods indicated no significant difference among the five methods with AUC values > 0.7 (*P* > 0.05, Fig. 2). Among them, the modified version of the Caprini method, the Swedish method, and the Shanghai method performed better than the six other methods with AUC values < 0.7 (*P* < 0.05, Fig. 3), as shown in Table 3.

According to the recommendations for the evaluation methods, the recommended drug prophylaxis ratio of the 220 puerperae was calculated. The recommended proportions (i.e., sensitivity) of drug prophylaxis in the VTE group, from high to low, were the modified Caprini, the Shanghai method, and the Chinese consensus; the specificity of the methods for the control group from high to low were the modified Padua and the ACOG, followed by the others (Tables 4 and 5).

The sensitivity of the modified Caprini method was higher than that of the Chinese consensus, RCOG, and Swedish methods (*P* < 0.05), but the specificity was only 25.45%. No significant difference in the sensitivities was detected between the Swedish, Shanghai, RCOG, and Chinese consensus methods (*P* > 0.05), whereas the specificity of the Swedish method was higher than that of the Shanghai, RCOG, and Chinese consensus methods (*P* < 0.05).

4. Discussion

In this study, the predictive values of the seven quantitative and four non-quantitative risk assessment methods for puerperal VTE were compared, and the modified Caprini was the best (AUC ranking). Taking the sensitivity and specificity of the recommended drug prevention as indicators, the AUC value of the Swedish method was superior after a pairwise comparison.

VTE risk assessment is challenging when trying to prevent or treat pregnancy-related VTE. Due to the lack of pharmaco-economic studies on pregnancy-related thromboprophylaxis, there is no consensus on the risk threshold for initiating pharmacoprophylaxis. The recommended VTE risk threshold for initiating drug prophylaxis during the puerperal period is 1–3% [3,14]. The remaining most guidelines and scales do not define this threshold for prevention, which is one of the reasons why there is currently no consensus on the best assessment method. We found that the recommended drug prevention rate of the RCOG assessment scale for the VTE group was 76.36% [6], and the drug prevention rate for the control group was 44.24%, which are similar to the results of previous studies. Daniela et al. used the RCOG assessment scale to evaluate 638 women without puerperal VTE, and the proportion of recommended drug prophylaxis was 53% [15]. This high drug prevention rate in the control group may lead to the use of low molecular weight heparin. In this study, the comprehensive AUC value and the sensitivity and specificity evaluation of drug prophylaxis showed that the

Table 1
General information.

	Venous thromboembolism (VTE) group (n = 55)	Control group (n = 165)	P
Age (years)	34 ± 6	31 ± 5	0.000
Age ≥35 (years)	27 (49.1%)	44 (26.7%)	0.002
Pre-pregnancy body mass index	23 ± 4	21 ± 3	0.034
Pre-pregnancy body mass index ≥30	2 (3.6%)	3 (1.8%)	0.601
History of VTE	0	0	0.000
Family history of VTE	0	1 (0.6%)	1.000
Varicose veins	1 (1.8%)	3 (1.8%)	1.000
Nephrotic syndrome	2 (3.6%)	4 (2.4%)	0.641
Assisted reproductive technology	11 (20.0%)	19 (11.5%)	0.112
Para ≥3	1 (1.8%)	2 (1.2%)	1.000
Twin pregnancy	7 (12.7%)	13 (7.9%)	0.279
Gestational diabetes mellitus	15 (27.3%)	26 (15.8%)	0.058
Eclampsia/preeclampsia	8 (14.5%)	11 (6.7%)	0.094
Infection	16 (29.1%)	18 (10.9%)	0.001
Cesarean section	51 (92.7%)	93 (56.4%)	0.000
Forceps delivery	1 (1.8%)	6 (3.6%)	0.683
Premature birth	29 (52.7%)	43 (26.1%)	0.000
Postpartum hemorrhage ^a	6 (10.9%)	6 (3.6%)	0.078
Transfer to intensive care unit	14 (25.5%)	8 (4.8%)	0.000
Newborn birth weight (g)	2787 ± 749	2940 ± 685	0.158
Therapeutic termination of pregnancy (fetal loss) ^b	4 (7.3%)	8 (4.8%)	0.741

^a Vaginal delivery ≥500 mL, cesarean section ≥1000 mL.

^b Serious maternal complications, fetal chromosomal/structural abnormalities, premature rupture of the membranes <24 weeks.

Table 2

Predictive values of venous thromboembolism risk assessment methods during the puerperium.

Assessment scale	Area under the curve (AUC)	95%CI	P	Youden index	Cutoff value	AUC value after joint prediction (P < 0.05)
Caprini	0.805	0.746–0.855	<0.001	0.4424	4	0.854
Swedish	0.779	0.719–0.832	<0.001	0.4667	1	0.847
Shanghai	0.774	0.713–0.828	<0.001	0.3939	1	0.837
RCOG	0.746	0.683–0.802	<0.001	0.3455	2	0.826
Chinese Consensus	0.742	0.679–0.799	<0.001	0.4848	/	0.840
PHP	0.687	0.622–0.748	<0.001	0.3333	0.5	0.799
QLD	0.679	0.613–0.740	<0.001	0.3576	/	0.796
SOGC	0.673	0.606–0.734	<0.001	0.3455	/	0.794
Padua	0.639	0.572–0.703	<0.001	0.2727	0	0.786
Bretelle	0.622	0.554–0.686	0.004	0.1879	0	0.787
ACOG	0.588	0.520–0.654	<0.001	0.1758	/	0.763

These brief names refer to the Swedish risk assessment scale, the pregnancy health-care program (PHP) risk assessment scale, the royal college of obstetricians and gynaecologists (RCOG) risk assessment scale, the modified Caprini risk assessment scale, the modified Padua risk assessment scale, the risk assessment scale from Bretelle, the Shanghai risk assessment scale, the Chinese consensus assessment, the Queensland (QLD) risk assessment, the American college of obstetricians and gynecologists (ACOG) risk assessment, and the Society of Obstetricians and Gynaecologists of Canada (SOGC) risk assessment.

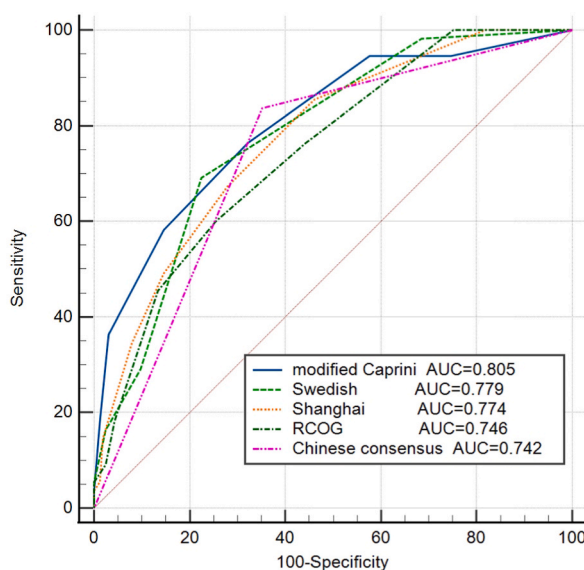


Fig. 2. Receiver operating characteristic curve of the assessments (the modified Caprini risk assessment scale, the Swedish risk assessment scale, the Shanghai risk assessment scale, the royal college of obstetricians and gynaecologists-RCOG risk assessment scale, the Chinese consensus assessment). AUC, area under the curve.

Swedish method was superior; and there were five risk assessments for puerperal VTE with AUC values > 0.7 in addition to personal VTE history and items related to hereditary thrombophilia. They are Swedish method (10 items), modified Caprini (15 items), Chinese consensus (16 items), RCOG method (19 items), Shanghai method (23 items), and there was no statistical difference in the AUC value or sensitivity. The specificity of the Swedish method was better than that of the other four methods ($P < 0.05$), indicating that an increase in the number of items does not necessarily significantly improve sensitivity, but it may reduce specificity.

Many VTE risk assessment methods can be used during the puerperium. The recommended drug prevention rates of the evaluation methods varied greatly, and the Swedish method was recommended, but further verification is needed in a large-sample prospective study due to the level of evidence in our study. Therefore, one limitation was the small sample size; future larger studies may obtain more accurate results. Personal histories of thrombosis and thrombophilia are strong risk factors. Heritable thrombophilia is found in 20–50% of pregnancy-related VTE [16]. Hereditary thrombophilia was associated with an elevated absolute risk of pregnancy-related VTE up to 0.3–18% [17]. Besides a personal VTE history or heritable thrombophilia, which are rare, the common risk factors of pregnancy-associated VTE are intermediate or low risk factors, such as cesarean delivery, obesity, pre-eclampsia, infections, and other pregnancy complications. Of the women, 75% had at least one VTE risk factor and more than 40% had two or more factors [18]. Pharmacoprophylaxis with prior VTE or heritable thrombophilia, rather than routine heritable thrombophilia screening, is considered. None of our subjects had a history of venous thromboembolism or was screened because of heritable thrombophilia. The predictive value of the methods may have been underestimated. This is another study limitation.

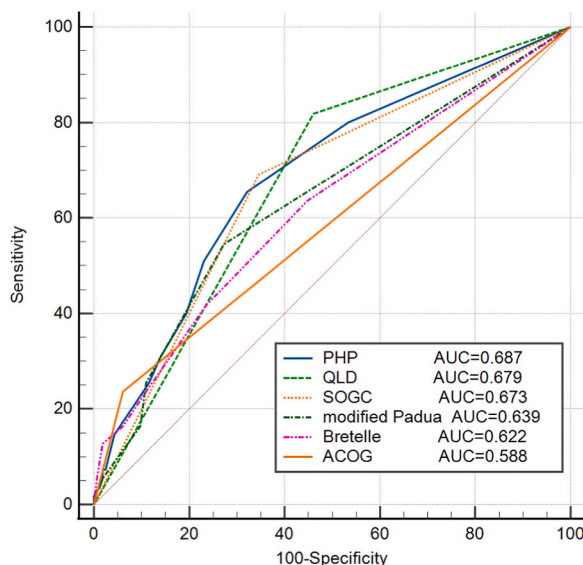


Fig. 3. Receiver operating characteristic curve of the assessments (the pregnancy health-care program-PHP risk assessment scale, the Queensland-QLD risk assessment, the society of obstetricians and gynaecologists of Canada-SOGC risk assessment, the modified Padua risk assessment scale, the risk assessment scale from Bretelle, the American college of obstetricians and gynaecologists-ACOG risk assessment). AUC, area under the curve.

Table 3
The area under curve of these risk assessment methods during the puerperium (P value).

Method	AUC	Caprini	Swedish	Shanghai	RCOG	Chinese	PHP	QLD	SOGC	Padua	Bretelle
Caprini	0.805										
Swedish	0.779	0.40									
Shanghai	0.774	0.38	0.86								
RCOG	0.746	0.11	0.24	0.18							
Chinese	0.742	0.09	0.27	0.24	0.91						
PHP	0.687	<0.01	<0.01	0.02	0.08	0.20					
QLD	0.679	<0.01	<0.01	<0.01	<0.01	0.07	0.81				
SOGC	0.673	<0.01	<0.01	<0.01	0.01	0.08	0.70	0.83			
Padua	0.639	<0.01	<0.01	<0.01	0.01	<0.01	0.16	0.33	0.41		
Bretelle	0.622	<0.01	<0.01	<0.01	<0.01	0.01	0.06	0.10	0.23	0.71	
ACOG	0.588	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	0.02	0.03	0.12	0.43

These brief names refer to the Swedish risk assessment scale, the pregnancy health-care program (PHP) risk assessment scale, the royal college of obstetricians and gynaecologists (RCOG) risk assessment scale, the modified Caprini risk assessment scale, the modified Padua risk assessment scale, the risk assessment scale from Bretelle, the Shanghai risk assessment scale, the Chinese consensus assessment, the Queensland (QLD) risk assessment, the American college of obstetricians and gynecologists (ACOG) risk assessment, and the Society of Obstetricians and Gynaecologists of Canada (SOGC) risk assessment.

Table 4
The sensitivity comparison of assessment methods (P value).

Methods	Threshold	Sensitivity	Caprini	Shanghai	Chinese	RCOG
Caprini	≥3	94.55%				
Shanghai	≥2	85.45%	0.18			
Chinese	/	83.64%	0.03	1.00		
RCOG	≥2	76.36%	0.01	0.23	0.42	
Swedish	≥2	69.09%	<0.01	0.05	0.08	0.34

These brief names refer to the Swedish risk assessment scale, the royal college of obstetricians and gynaecologists (RCOG) risk assessment scale, the modified Caprini risk assessment scale, the Shanghai risk assessment scale, the Chinese consensus assessment.

One strength of our study is the analysis of the applicability of different guidelines based on a homogeneous population. This is important in clinical practice. In addition, we quantified these assessments to compare their clinical application value as a reference more accurately.

In general, among the 11 evaluation methods, the Swedish method had particular clinical application value. Future research should

Table 5
The specificity comparison of assessment methods (P value).

Methods	Threshold	Specificity	Swedish	Chinese	RCOG	Shanghai
Swedish	≥2	77.58%				
Chinese	/	64.85%	<0.01			
RCOG	≥2	55.76%	<0.01	<0.01		
Shanghai	≥2	53.94%	<0.01	<0.01	0.55	
Caprini	≥3	25.45%	<0.01	<0.01	<0.01	<0.01

These brief names refer to the Swedish risk assessment scale, the royal college of obstetricians and gynaecologists (RCOG) risk assessment scale, the modified Caprini risk assessment scale, the Shanghai risk assessment scale, the Chinese consensus assessment.

explore the value of the scored items, and develop a simple and easy risk assessment scale for early prevention of VTE in high-risk groups.

5. Conclusion

The predictive value of different risk assessment methods for puerperium VTE varies greatly. Considering the sensitivity and specificity, the Swedish method may have better clinical application value among the 11 methods.

Declaration

Author contribution statement

Xianggui Luo: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Wrote the paper. Qi Li: Conceived and designed the experiments; Wrote the paper. Jingrui Huang: Performed the experiments; Wrote the paper. Jiahao Zhu, Yi Huang, Weishe Zhang: Analyzed and interpreted the data. Renhui Zhou, Xiangning Tu, Qiaohong Guo, Shuzhen Yuan, Yanhua Zhao, Chenlin Pei, Xinhua Wu: Contributed reagents, materials, analysis tools or data.

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Data availability statement

Data will be made available on request.

Declaration of interest's statement

The authors declare no competing interests.

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