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Original Research

Comparison of Risk Assessment Models for Predicting Postpartum Venous Thromboembolism

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Abstract

Background: Venous thromboembolism (VTE) remains a leading cause of sudden death in obstetric patients. Despite advancements in diagnostic and therapeutic approaches, the incidence of VTE continues to rise. This study aimed to validate the accuracy of currently used risk assessment models (RAMs) for predicting postpartum VTE. **Methods**: This retrospective study was conducted from February 2019 to February 2024. The Chinese Expert Consensus on the Prevention and Treatment of VTE during Pregnancy and Puerperium (Chinese Consensus), and the Queensland Clinical Guideline (QLD guideline) were used to evaluate VTE risk. Risk factors were compared between the VTE group and the control groups. The predictive performance of the two RAMs was assessed by analyzing the area under the curve (AUC) of the receiver operating characteristic (ROC). **Results**: A total of 560 postpartum women were included, comprising 140 cases with VTE and 420 cases without VTE (controls). Significant differences between the two groups were observed for D-dimer levels, platelet (PLT) count, length of hospital stay, gestational age, body mass index (BMI) $\geq$25 kg/m^2, postpartum hemorrhage (PPH), premature birth, and delivery mode (all $p < 0.05$). A higher proportion of anti-phospholipid antibody positivity was found in the VTE group (p = 0.054), while assisted reproductive technology (ART), emergency cesarean delivery, and elevated total cholesterol levels were more frequent in the control group ($p < 0.05$). Cesarean delivery was the most frequent risk factor triggering VTE, followed by age $\geq$35 years, and ART. However, stillbirth (n = 2, 66.7%), anti-phospholipid antibody positivity (n = 9, 52.9%), and PPH (n = 13, 52%) demonstrated the highest proportions of VTE. Notably, VTE occurred in the low-risk group, with an incidence of 20.6% according to the QLD guideline and 24.6% according to the Chinese Consensus. 2 VTE cases were observed in patients with a score of 0. The QLD guideline exhibited higher sensitivity than the Chinese Consensus (0.81 *vs.* 0.69), but lower specificity (0.64 *vs.* 0.83). The AUCs for predicting postpartum VTE were 0.624 ($p < 0.001$) for the QLD guideline and 0.538 ($p > 0.05$) for the Chinese Consensus. **Conclusions**: PPH, anti-phospholipid antibody positivity, and D-dimer levels were closely associated with thrombosis. Both the QLD guideline and the Chinese Consensus showed suboptimal performance in estimating VTE risk. Further research is urgently needed to develop more effective RAMs to aid in the prevention of postpartum VTE.

Keywords: venous thromboembolism (VTE); postpartum; risk assessment models (RAMs)

1. Introduction

Venous thromboembolism (VTE) is a common condition with an average incidence of 1 to 2 cases per 1000 pregnancies, including pulmonary embolism (PE) and deep vein thrombosis (DVT) [1,2]. Physiological and hormonal changes during pregnancy and the postpartum period can increase the risk of VTE. Compared with non-pregnant women, the incidence of VTE in antepartum and postpartum women is 3–10 times and 12–35 times higher, respectively [3,4]. Although it is potentially preventable, the incidence of obstetric VTE has been increasing yearly in China [5]. Some women still develop VTE despite receiving prophylaxis, with the underlying reasons remaining unclear. Currently, significant controversy surrounds the use of thromboprophylaxis in postpartum women, and a suitable VTE risk assessment model (RAM) has yet to be established.

In recent years, various RAMs and guidelines for the prevention of VTE during pregnancy and the puerperium have been developed. These include the Royal College of Obstetricians and Gynecologists (RCOG) guidelines [6], the American College of Obstetricians and Gynecologists (ACOG) Practice Bulletins [7], the Society of Obstetricians and Gynecologists of Canada (SOGC) risk assessment [8], the Swedish Guidelines (Swedish method) [9] and the Queensland Clinical Guideline (QLD guideline) (**Supplementary Fig. 1**) [10]. However, the risk factors included in these RAMs are not consistent, and their predictive value for puerperal VTE varies significantly. Moreover, several studies have suggested that VTE risk assessment tools developed in Western countries may not be directly applicable to Chinese populations [11–13]. To address this, the Chinese Expert Consensus on the Prevention and Treatment of VTE during Pregnancy and Puer-

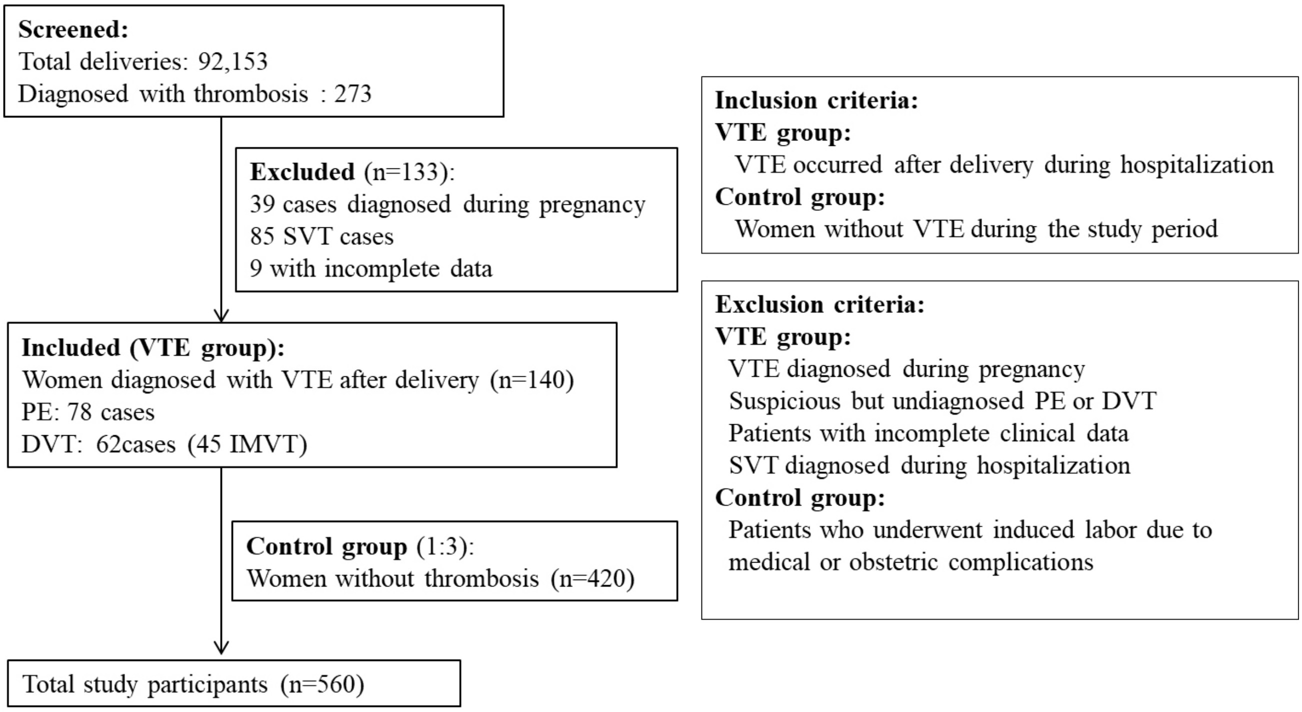

Fig. 1. Flowchart showing the selection of study participants. VTE, venous thromboembolism; PE, pulmonary embolism; DVT, deep vein thrombosis; SVT, superficial venous thrombosis; IMVT, intermuscular venous thrombosis.

perium (Chinese Consensus) was developed in 2021 and subsequently promoted across many hospitals in China (**Supplementary Table 1**) [14].

In our hospital, the QLD guideline was widely applied in previous years, but was replaced by the Chinese Consensus in 2021. The QLD guideline incorporates relevant risk factors and provides recommendations for the duration of anticoagulation maintenance. However, it does not specify the timing for the initiation of postnatal anticoagulation treatment. On the other hand, the Chinese Consensus does not include certain risk factors, such as premature birth, diabetes mellitus, assisted reproductive technology (ART), vaginal delivery transfer cesarean section, cesarean hysterectomy, and stillbirth. Additionally, it specifies the timing of anticoagulation initiation postpartum and the duration of treatment according to different risk scores. Therefore, the predictive ability of these two models requires further validation.

The primary objectives of this study were to analyze the relationship between various risk factors and VTE, and to compare the predictive value of the QLD guideline and the Chinese Consensus in assessing VTE risk.

2. Materials and Methods

2.1 Study Design

This retrospective study was conducted at the West China Women's and Children's Hospital of Sichuan University from February 2019 to February 2024, during which there were 92,153 deliveries. All women diagnosed with puerperal VTE during hospitalization were assigned to the VTE group. Controls were randomly selected at a 1:3 ratio from women without puerperal VTE during the same recruitment period, given the extensive number of risk factor indicators incorporated in each model. Informed consent was obtained from each participant, and the study was approved by the Medical Ethics Committee of the West China Women's and Children's Hospital of Sichuan University (approval number: 2024195).

Inclusion criteria: VTE occurring after delivery and during hospitalization at our institute. Control group: postpartum women who did not develop VTE during the study period.

Exclusion criteria: ① VTE diagnosed during pregnancy; ② Suspicious but undiagnosed PE or DVT; ③ Patients with incomplete clinical data; ④ Superficial venous thrombosis (SVT) occurring during hospitalization. Control group: patients who underwent induced labor due to medical or obstetric complications after hospital admission.

Diagnosis standard: PE was confirmed by computed tomography pulmonary angiography (CTPA), while DVT was diagnosed by color Doppler ultrasonography. The selection process is shown in Fig. 1.

Demographic and clinical data were collected for each participant, including age, body mass index (BMI) before delivery, length of hospital stay, gestational age at delivery, history of VTE, and family history of VTE. Data on pregnancy-associated risk factors was also collected, including ART, delivery mode (vaginal delivery, elective cesarean delivery, emergency cesarean delivery, vaginal delivery transfer cesarean), premature birth, stillbirth in the current pregnancy, parity $\geq$3, postpartum hemorrhage (PPH: defined as blood loss $\geq$1000 mL or requiring blood transfusion), preeclampsia, postnatal infection, and prolonged labor ($\geq$24 hours). Maternal comorbidities were also recorded, including cancer, heart failure, severe pulmonary disease, inflammatory bowel disease and sickle cell anemia, as well as autoimmune diseases such as antiphospholipid syndrome (APS), systemic lupus erythematosus (SLE) and Sjögren's syndrome. Antenatal immobility (defined as bed rest for $\geq$7 days) was also included. Lastly, data on various laboratory parameters was collected, including D-dimer after delivery, total cholesterol, triglycerides before delivery, and platelet (PLT) after delivery.

The classification criteria for indicators such as age, BMI, parity and PPH were based on the thresholds defined in the QLD guideline and the Chinese Consensus for predicting postpartum VTE. Specifically, BMI was categorized as $\geq$25 kg/m^2 and $\geq$30 kg/m^2. The BMI $\geq$25 kg/m^2 cutoff was selected because our analysis indicated that BMI $\geq$30 kg/m^2 did not show a statistically significant association with postpartum VTE. Moreover, BMI $\geq$25 kg/m^2 was recognized as a risk factor in the Caprini RAM [15], thereby supporting its relevance and applicability in our analysis. Based on the Caprini scoring model, we also included anticardiolipin antibody positivity and lupus anticoagulant positivity in the analysis. These were classified as anti-phospholipid antibody positivity (anti-phospholipid antibody [+]), with some patients diagnosed with APS.

The dataset did not include information on history of VTE, family history of VTE, contraceptive use before pregnancy, and known thrombophilias. Consequently, these factors were incorporated into the "other factors" category. To eliminate the bias in platelet counts caused by thrombocytopenia, patients with PLT $<$100 $\times$ 10^9/L were excluded from the final analysis of platelets.

VTE scores before delivery were assessed upon admission for all participants, while the scores after delivery were evaluated within 24 h postpartum. Risk stratification was defined according to the guidelines: a score of 0 or 1 was classified as low risk, 2 as moderate risk and $\geq$3 as high risk. Risk factors were compared between the VTE and control groups, and the distribution of relevant risk factors across different types of VTE was analyzed. Each model was constructed using its respective set of recommended risk factor indicators, without integration or modification. Finally, the AUCs of ROC and sensitivity analyses were calculated to determine the predictive value of the QLD guideline and Chinese Consensus.

2.2 Statistical Analysis

Results were tabulated and analyzed using the Statistical Package for Social Sciences (SPSS, version 25.0, IBM, Chicago, IL, USA). Continuous variables were tested for normality using the Shapiro-Wilk test. Non-normally distributed variables were presented as the median (Q1, Q3) and compared using the Mann-Whitney U test. Categorical data were expressed as percentages and assessed with the Chi-square test or Fisher's exact test. We used the Chi-Square Test to examine the overall statistical differences. On this basis, Bonferroni correction was applied for pairwise comparisons to further clarify whether there were significant differences between specific groups. The prediction effect of the scale was evaluated by the AUC of ROC. For all tests, a p-value $<$ 0.05 was considered to indicate statistical significance.

3. Results

A total of 140 patients were included in the VTE group, comprising 78 cases of PE and 62 cases of DVT. A further 420 women without VTE were recruited as the control group (Fig. 1).

The baseline characteristics and risk factors for the VTE and control groups are summarized in Table 1. The length of hospital stay, D-dimer and PLT were significantly higher in the VTE group ($p < 0.05$) compared to the control group, while the gestational age was shorter ($p < 0.001$) and the total cholesterol level was lower ($p < 0.05$) (Table 1).

Significant differences were also observed between the VTE and control groups for BMI $\geq$25 kg/m^2, PPH, premature birth and cesarean delivery ($p < 0.05$). Specifically, the proportion of women undergoing elective cesarean delivery and vaginal delivery transfer cesarean were all higher in the VTE group ($p < 0.05$), while the proportion of women undergoing emergency cesarean delivery was higher in the control group ($p < 0.05$). Additionally, the VTE group showed a higher proportion of antiphospholipid antibody (+) compared to the control group (p = 0.054), highlighting its potential clinical relevance. Conversely, the proportion of ART use was higher in the control group (p = 0.001).

No significant differences were found between the two groups for the other risk factors analyzed, including age $\geq$35 years, BMI $\geq$30 kg/m^2, triglycerides, multiple pregnancy, preeclampsia, parity $\geq$3, stillbirth, pre-existing diabetes, maternal comorbidities, and other evaluated factors.

Interestingly, scores for the Chinese Consensus were not significantly different between the VTE and control groups, either before or after delivery. In contrast, scores for the QLD guideline were significantly higher after delivery in the VTE group compared to the control group ($p <$ 0.001).

Trigger frequency of different risk factors was shown in Table 2. Cesarean delivery was identified as the most frequent risk factor for VTE, followed by age $\geq$35 years, ART, premature birth, multiple pregnancy, vaginal delivery transfer cesarean, BMI $\geq$30 kg/m^2, preeclampsia, PPH, parity $\geq$3, pre-existing diabetes, maternal comorbidities and stillbirth.

Table 1. Comparison of the basic characteristics and risk factors between the VTE and control groups.

Characteristics and risk factors	VTE group (n = 140)	Control group (n = 420)	Z/χ^2	*p*-value
Age (years)	33 (29.75, 36.0)	32 (29.5, 35.5)	–0.75	0.453
BMI (kg/m^2)	26.96 (25.46, 28.12)	26.81 (24.83, 28.81)	–1.821	0.069
Length of stay (days)	7 (6, 12)	4 (3, 6)	–10.776	<0.001
Gestational age at delivery (weeks)	37+2 (36+0, 39+4)	38+2 (36+0, 39+4.5)	–3.818	<0.001
D-dimer (mg/L)	3.45 (1.92, 7.9)	2.27 (1.5, 3.57)	–4.686	<0.001
PLT (10^9/L)	190 (149, 226)	174 (141, 207)	–2.644	0.008
Total cholesterol (mmol/L)	5.89 (4.87, 6.75)	6.71 (5.78, 7.62)	–2.612	0.009
Triglycerides (mmol/L)	3.57 (2.59, 4.9)	4.25 (3.03, 5.23)	–0.520	0.603
Age ≥35 (years)	55 (39.3%)	195 (46.4%)	2.168	0.141
BMI ≥30 (kg/m^2)	18 (12.9%)	42 (10%)	0.896	0.344
BMI ≥25 (kg/m^2)	108 (77.1%)	286 (68.1%)	4.121	0.042
Multiple pregnancy	36 (25.7%)	85 (20.2%)	1.859	0.173
Parity ≥3	4 (2.9%)	19 (4.5%)	0.741	0.389
PPH	13 (9.3%)	12 (2.9%)	10.174	0.001
Preeclampsia	14 (10%)	28 (6.7%)	1.682	0.195
Anti-phospholipid antibody (+)	9 (6.4%)	12 (2.9%)	3.711	0.054
Premature birth	46 (32.9%)	81 (19.3%)	11.029	0.001
Pre-existing diabetes	3 (2.1%)	11 (2.6%)		1.000[b]
ART	37 (26.4%)	177 (42.1%)	10.982	0.001
Stillbirth in current pregnancy	2 (1.4%)	1 (0.2%)		0.156[b]
[a] Maternal comorbidities and others	6 (4.3%)	8 (1.9%)	1.524	0.217[c]
Delivery mode			26.343	<0.001
Vaginal delivery	5 (3.6%)	56 (13.3%)	10.309	0.001
Cesarean delivery	135 (96.4%)	364 (86.7%)	10.309	0.001
Elective cesarean delivery	70 (50%)	162 (38.6%)	5.652	0.017
Emergency cesarean delivery	37 (26.4%)	162 (38.6%)	6.758	0.009
Vaginal delivery transfer cesarean	28 (20%)	40 (9.5%)	10.802	0.001
Score before delivery				
QLD guideline	1 (0, 2)	1 (0, 2)	–1.658	0.097
Chinese Consensus	1 (0, 1)	1 (0, 1)	–0.234	0.815
Score after delivery				
QLD guideline	3 (2, 4)	2 (2, 3)	–4.558	<0.001
Chinese Consensus	2 (1, 3)	2 (1, 2)	–1.461	0.144

[a] Maternal comorbidities and other factors including VTE history, VTE family history, cancer, heart failure, infection, prolonged labor, cesarean hysterectomy, gross varicose veins, immobility, oral contraceptive use, etc. [b] Denotes statistical analysis performed using Fisher's exact test. [c] Calculated using Yates' continuity correction. Note: The classification criteria for each indicator are based on the QLD guideline and the Chinese Consensus. ART, assisted reproductive technology; PPH, postpartum hemorrhage ≥1000 mL or blood transfusion; BMI, body mass index; PLT, platelet; QLD, Queensland clinical.

Fig. 2 visually presents the proportion of VTE cases amongst the different risk factors. The highest incidence of VTE was observed in cases of stillbirth (66.7%), followed by anti-phospholipid antibody (+) (52.9%), PPH (52%), maternal comorbidities (42.9%), vaginal delivery transfer cesarean (41.2%), premature birth (36.2%), preeclampsia (33.3%), BMI ≥30 kg/m^2 (30%), multiple pregnancy (29.8%), cesarean delivery (24.8%), age ≥35 years (22%), pre-existing diabetes (21.4%), parity ≥3 (17.4%) and ART (17.3%).

Table 3 shows the relationship between the scores from the two RAMs and the incidence of VTE. As the scores increased, the incidence of VTE also rose, with the highest occurrence observed in patients scoring 3 or above ($p < 0.05$). However, VTE still occurred in the low-risk group (score of 0 or 1), with an incidence of 20.6% using the QLD guideline and 24.6% using the Chinese Consensus. Notably, two cases of VTE were observed in patients scored as 0 with both RAMs. Moreover, with both RAMs the proportion of VTE in patients with a score of 1 was higher than in those with a score of 2, although this difference was not statistically significant. The QLD guideline identified a slightly higher proportion of high-risk patients (34.6%) than the Chinese Consensus (31.4%).

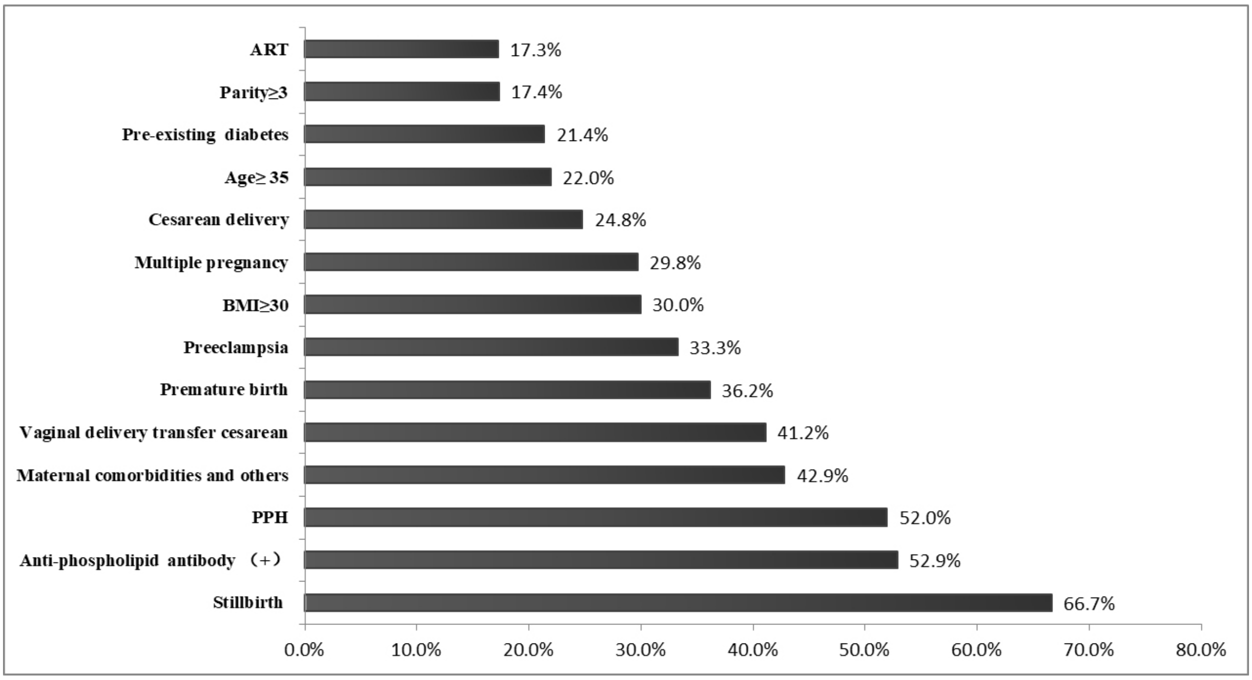

Fig. 2. The proportion of VTE cases amongst different risk factor groups. ART, assisted reproductive technology.

Table 2. Trigger frequency of different risk factors and incidence of VTE in the two RAMs.

Risk factors	QLD guideline		Chinese Consensus	
	Frequency	VTE	Frequency	VTE
Cesarean delivery	431	107 (24.8%)	499	135 (27.1%)
Age ≥35 (years)	250	55 (22.0%)	250	55 (22.0%)
ART	214	37 (17.3%)		
Premature birth	127	46 (36.2%)		
Multiple pregnancy	121	36 (29.8%)	121	36 (29.8%)
Vaginal delivery transfer cesarean	68	28 (41.2%)		
BMI ≥30 (kg/m^2)	60	18 (30.0%)	60	18 (30.0%)
Preeclampsia	42	14 (33.3%)	42	14 (33.3%)
PPH	25	13 (52.0%)	25	13 (52.0%)
Parity ≥3	23	4 (17.4%)	23	4 (17.4%)
Pre-existing diabetes	14	3 (21.4%)		
Maternal comorbidities and others	14	6 (42.9%)	14	6 (42.9%)
Stillbirth in current pregnancy	3	2 (66.7%)		

Note: ART, assisted reproductive technology; PPH, postpartum hemorrhage ≥1000 mL or blood transfusion.

Finally, as detailed in Table 4 and Fig. 3, the QLD guideline demonstrated an AUC of 0.624 for the prediction of VTE, with a sensitivity of 0.81, specificity of 0.64, positive predictive value (PPV) of 0.43 and negative predictive value (NPV) of 0.91. In comparison, the Chinese Consensus showed an AUC of 0.538, with a sensitivity of 0.69, specificity of 0.83, PPV of 0.58, and NPV of 0.89.

4. Discussion

VTE is a severe maternal complication during the antenatal or postpartum period [1,16,17]. Despite the improved preventive measures for obstetric VTE in recent years, its incidence continues to rise. Many women still experience VTE even after prophylactic measures have been implemented, leading to increased treatment costs and prolonged hospital stays [18,19]. This retrospective study analyzed obstetric women admitted to our hospital over the past five years, focusing on the relationship between various risk factors and the incidence of postpartum VTE. In particular, we compared the predictive accuracy of the QLD guideline and the Chinese Consensus for VTE.

The average age of pregnant women in China has increased in recent years, which may be related to the adjustment to China's three-child policy. Although the BMI of

Table 3. The relationship between the scores from the two RAMs and the occurrence of VTE.

Risk level	Scores	QLD guideline			Chinese Consensus		
		Total	VTE (n, %)	Control (n, %)	Total	VTE (n, %)	Control (n, %)
	0	38	2 (5.3%)	36 (94.7%)	40	2 (5.0%)	38 (95.0%)
Low risk	1	88	24 (27.3%)	64 (72.7%)	143	43 (30.1%)	100 (69.9%)
	0–1	126	26 (20.6%)	100 (79.4%)	183	45 (24.6%)	138 (75.4%)
Mod. risk	2	203	34 (16.7%)	169 (83.3%)	275	63 (22.9%)	212 (77.1%)
High risk	≥3	231	80 (34.6%)*	151 (65.4%)	102	32 (31.4%)*	70 (68.6%)
Total		560			560		
p-value			<0.001			0.002	

* Indicates a statistical difference. For QLD guideline, * (scores ≥3) was compared to scores = 0 and scores = 2. For Chinese Consensus, * (scores ≥3) was compared to scores = 0.

Table 4. Predictive ability of the QLD guideline and Chinese Consensus for postpartum VTE.

RAMs	AUC (95% CI)	Sensitivity (95% CI)	Specificity (95% CI)	PPV (95% CI)	NPV (95% CI)	*p*-value
QLD guideline	0.624 (0.57–0.68)	0.81 (0.74–0.87)	0.64 (0.59–0.69)	0.43 (0.37–0.49)	0.91 (0.87–0.94)	<0.001
Chinese Consensus	0.538 (0.48–0.59)	0.69 (0.60–0.71)	0.83 (0.80–0.87)	0.58 (0.50–0.65)	0.89 (0.86–0.92)	0.175

RAMs, risk assessment models; AUC, area under the curve; PPV, positive predictive value; NPV, negative predictive value.

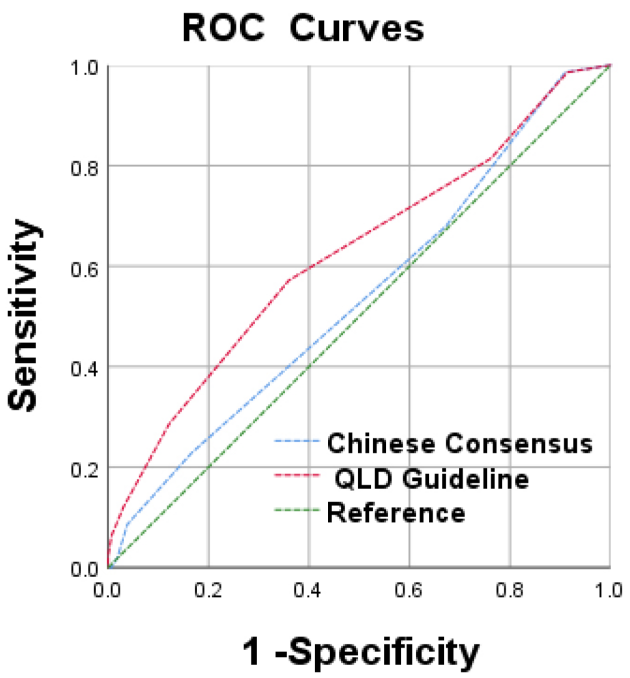

Fig. 3. AUC of the QLD guideline and the Chinese Consensus for the prediction of VTE. ROC, receiver operating characteristic; AUC, area under the curve.

pregnant women has also risen, no significant differences in age or BMI ≥30 kg/m^2 were found between the VTE and control groups, consistent with previous reports [11,12]. However, factors such as BMI ≥25 kg/m^2, PPH, preterm birth, and the vaginal delivery transfer cesarean section were found to have significant associations with VTE. Additionally, anti-phospholipid antibodies (+) showed a potential closely association with VTE. Despite these findings, neither the QLD guideline nor the Chinese Consensus fully incorporates these factors. For example, preterm birth and vaginal delivery transfer cesarean are not included in the Chinese Consensus. These omissions may partly explain the limited predictive value of both models.

Preeclampsia plays an important role in the occurrence of postpartum VTE, due to its association with increased levels of coagulation factors and reduced fibrinolytic activity [20,21]. However, the present study did not find a significant relationship between preeclampsia and postpartum VTE. A similar result was also found for ART, consistent with findings from previous studies [12,22,23]. In addition, the study may indicate a potential relationship between stillbirth and VTE, but the small sample size is insufficient to draw definitive conclusions regarding their association. Further research is required to evaluate the impact of these factors on the risk of postpartum VTE.

Two patients who were classified as low-risk (0 points) in this study by both the QLD guideline and the Chinese Consensus nevertheless experienced VTE. Neither patient had associated risk factors from the QLD guideline and Chinese Consensus, but their D-dimer level was elevated (4.17 mg/L and 12.97 mg/L). Interestingly, the median D-dimer level in the VTE group was significantly higher than in the control group, suggesting that elevated levels of this marker indicate thrombosis, even in patients classified as low-risk. This finding was similar to that of other previous reports [22,23]. The incidence of VTE in the low-risk group was unacceptably high (20%–25%), highlighting the weak predictive accuracy of both RAMs.

Effective prevention strategies for VTE rely on accurate risk assessment, but in this study both the QLD guideline and the Chinese Consensus showed suboptimal accuracy. Potential reasons for this are firstly the underestimation of VTE risk due to the inclusion of inappropriate or incomplete risk factors, leading to missed opportunities for standard thromboprophylaxis. For patients identified as high-risk by the RAMs who developed VTE, the reasons may include a lack of standardized thromboprophylaxis, or delays in initiating prophylaxis after delivery.

Several limitations should be considered when interpreting the results of this retrospective study. First, the characteristics of the control group are critical and may vary depending on the definition used, thus potentially introducing bias. Second, the sample size for certain subgroups, such as PE and DVT cases, was relatively small, thereby reducing the statistical power to detect differences. Third, the study was conducted at a single center, which may limit the generalizability of the findings to other healthcare settings.

5. Conclusions

The Chinese Consensus and the QLD guideline show limited predictive ability for VTE, highlighting the need to further refine the risk factors included in the RAMs. Additional studies are required to develop more effective RAMs for puerperal VTE, with the aim of better preventing postpartum VTE and thus reducing maternal mortality.

Abbreviations

QLD, Queensland clinical; VTE, Venous thromboembolism; PE, Pulmonary embolism; DVT, deep vein thrombosis; RAMs, risk assessment models; AUC, area under the curve; ROC, receiver operating characteristic; CTPA, computed tomography pulmonary angiography; BMI, body mass index; ART, assisted reproductive technology; APS, antiphospholipid syndrome; PPH, postpartum hemorrhage; PLT, platelet; SLE, systemic lupus erythematosus; IMVT, intermuscular venous thrombosis; SVT, superficial venous thrombosis; PPV, positive predictive value; NPV, negative predictive value.

Availability of Data and Materials

The data used and analyzed during the current study are available from the corresponding author on reasonable request via email.

Author Contributions

FX: study design and results interpretation. YX: data collection, data cleaning, data analysis and manuscript writing. SZ: data collection. JH: provided partial advices and results interpretation. XX: led protocol development and results interpretation. All authors contributed to editorial changes in the manuscript. All authors critically reviewed and approved the final manuscript. All authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work.

Ethics Approval and Consent to Participate

All subjects gave their informed consent for inclusion before they participated in the study. The study was conducted in accordance with the Declaration of Helsinki, and the protocol was approved by the Medical Ethics Committee of the West China Women's and Children's Hospital of Sichuan University (approval number: 2024195).

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Conflict of Interest

The authors declare no conflict of interest.

Declaration of AI and AI-Assisted Technologies in the Writing Process

During the preparation of this work, the authors used ChatGPT-4o in order to check spelling and grammar. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

Supplementary Material

Supplementary material associated with this article can be found, in the online version, at https://doi.org/10.31083/CEOG31322.

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