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Risk Assessment Models for Venous Thromboembolism in Gynecological Patients: A Review of Current Practices and Future Directions

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Abstract: This article introduces and compares risk assessment models for venous thromboembolism in gynecological patients at home and abroad. The models assessed included the Caprini risk assessment model, the G-Caprini risk assessment model, the Rogers risk assessment model, the Autar risk assessment model, the gynecological patient surgical venous thrombosis risk assessment scale, the Wells score, the COMPASS-CAT thrombus risk assessment model, the Khorana risk assessment model, the Padua risk assessment model, and the Chaoyang model. The purpose of this study is to provide a foundation for developing a risk assessment tool for gynecological venous thromboembolism tailored to Chinese patients and to assist clinical health care workers in selecting appropriate risk assessment tools and guiding individualized prevention measures.

Keywords: Gynecological patients; Venous thromboembolism; Risk assessment model; Review; Research progress

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1. Introduction

Venous thromboembolism (VTE) refers to the abnormal coagulation of blood in the veins, causing complete or incomplete blockage of blood vessels. VTE is a venous reflux disorder. Deep vein thrombosis (DVT) and pulmonary thromboembolism (PTE) are two manifestations of VTE that occur in different locations and stages [1]. Owing to factors such as the unique anatomical structure of gynecological diseases, open surgical procedures, malignant tumors, laparoscopic procedures, and hormone use [2], the risk of venous thromboembolism in patients with gynecological malignant tumors ranks second [3]. Previous research has shown that the relative risk of DVT can be reduced by 50–60%, and the relative risk of pulmonary embolism (PE) can be reduced by approximately two-thirds [4,5]. In 2017, the expert consensus on the prevention of deep vein thrombosis and

pulmonary embolism after gynecological surgery in China recommended VTE prevention measures on the basis of risk grading [6]. The importance of specific risk assessment of VTE cannot be underestimated, particularly when dealing with gynecological cancer patients [7]. Improving the accuracy of screening tools, reducing missed diagnosis rates, and providing early preventive measures on the basis of different risk classifications can help reduce the incidence and mortality of VTE in patients and improve their prognosis. A standardized, concise, and feasible diagnostic process can reduce the workload of medical staff and the medical expenses of patients [8]. This study reviews the clinical application of risk assessment models for venous thromboembolism in gynecological patients at home and abroad; compares the content, evaluation objects, risk stratification, clinical validation, and application effects of each model; and provides a basis for gynecological medical staff to select suitable risk assessment tools, accurately identify high-risk patients for gynecological venous thromboembolism, and intervene in a timely manner.

2. Current status and influencing factors of venous thromboembolism in gynecological patients

Previous epidemiological studies have demonstrated that the incidence of venous thromboembolism in gynecological patients is 15% to 40% [9]. In China, venous thromboembolism affects 9.2% to 15.6% of patients, and PE accounts for 46% of these patients [10]. According to a meta-analysis, the pooled incidence of postoperative symptomatic VTE is 3%, whereas that of asymptomatic VTE is 8% [11]. The incidence of postoperative DVT in gynecology is 0.08% to 2.15%, whereas the incidence of PE is 0.02% to 0.12%. In patients with gynecological malignant tumors, the incidence of postoperative VTE in gynecological malignant tumors ranges from 2.90% to 19.87% [12]. The risk factors for venous thromboembolism in gynecological patients include congenital and acquired risk factors. The main congenital risk factor for VTE in China is thrombophilia. For gynecological patients, the common acquired risk factors for VTE include nine categories, namely, advanced age (age ≥ 60 years) [13], obesity (body mass index [BMI] > 26 kg/m^2) [14], tumor pathology (tumor differentiation [GREAD3], tumor staging [stage IV]) [14,15], history of thrombosis [16], laboratory examination data (platelet count, D-dimer) [16], surgery-related factors (surgical methods [laparotomy and laparoscopic surgery] [14,16], surgical time [16], intraoperative blood loss [14], intraoperative pneumoperitoneum pressure) [17], long-term bed rest after surgery [14,15], radiotherapy and chemotherapy [15], and pregnancy [18]. Oral contraceptives (OC) and hormone replacement therapy (HRT) were used [19].

3. Risk assessment model for venous thromboembolism in gynecological patients

The risk assessment models for venous thromboembolism in gynecological patients include the Caprini risk assessment model [20], the G-Caprini risk assessment model [6], the Rogers risk assessment model [21], the Autar risk assessment model [22], the gynecological patient surgical venous thromboembolism risk assessment scale [23], the Wells score [24], the COMPASS-CAT thrombus risk assessment model [25], the Khorana risk assessment model [26], the Padua risk assessment model [27], and the Chaoyang model [28] (**Table 1**).

Table 1. Summary of risk assessment models for venous thromboembolism in gynecological patients

Number	Model name	Model development team	Model development time	Number of entries	Specific items	Scoring method	Classification of risks	Scope of application	Sensitivity and specificity
1	Caprini risk assessment model [20]	Caprini, a scholar from Northwestern University in the United States	2005	38	Patient's own factors, surgical factors, and clinical laboratory tests, etc.	Risk factors are scored 1–5 points, respectively	According to the total score, patients are divided into four groups: 0–1 is considered low-risk, 2 to <3 is considered moderate risk, 3–4 is considered high-risk, and ≥ 5 is considered extremely high-risk. Different preventive measures are recommended based on risk stratification.	Used for risk assessment of VTE in surgery.	The sensitivity ranges from 76.0% to 98.1%, and the specificity ranges from 7.5% to 64%.
2	G-Caprini risk assessment model [6]	Chinese Obstetrics and Gynecology Expert Team	2017	6	Age ≥ 50 years, hypertension, varicose veins, surgery time ≥ 3 hours, postoperative bed rest time ≥ 48 hours, open surgery	1 point per item	According to the total score, patients are classified into four risk levels: 0 is low-risk, 1 is moderate risk, 2 is high-risk, and ≥ 3 is extremely high-risk.	Patients undergoing gynecological-related surgeries	The sensitivity is 86.63% and the specificity is 87.93% [29].
3	Autar risk assessment model [22]	British nursing expert Autar	1996	7	Age, BMI, activity level, special risks, trauma risks, surgical risks, and high-risk diseases have increased, including age, hormone replacement therapy, surgical type, concomitant hemolytic anemia, and varicose veins	Risk factors are scored from 0 to 7 points, respectively	Three risk stratification: low-risk (≤ 10 points), moderate risk (11–14 points), and high-risk (≥ 15 points).	Trauma and orthopedic patients	The overall consistency percentage of the model is between 91% and 98%, the K value is between 0.88 and 0.95, the intra class correlation coefficient is between 0.94 and 0.99, and the sensitivity is 70% when the critical value is 11 points.
4	Rogers risk assessment model [21]	Rogers from Brigham and Women's Hospital, affiliated with Harvard Medical School, USA	2007	26	Gender, physical condition grading, ventilator dependence, wound type (clean/contaminated), cancer spread, etc.	Each item is worth 0–9 points	According to the total score, patients are divided into three groups: < 7 points for low-risk, 7–10 points for moderate risk, and > 10 points for high-risk.	Preoperative treatment for patients undergoing major surgery	The predictive model for postoperative VTE (c-index = 0.7647).
5	Padua risk assessment model [27]	Barbar University of Padua, Italy	2010	11	Active malignant tumor, history of VTE, and bed rest time > 3 days; recent (≤ 1 month) trauma or surgical operation; age ≥ 70 years, heart and/or respiratory failure, acute myocardial infarction and/or ischemic stroke, acute infection and/or rheumatic disease, obesity [body mass index (BMI) ≥ 30 kg/m^2], currently undergoing hormone therapy	Assign 1–3 points to risk factors	Patients with a total score of ≥ 4 are considered high-risk for thrombosis, whereas those with a score less than 4 are considered low-risk	Internal medicine inpatients	Sensitivity 94.6%, specificity 62%.

Table 1 (Continued)

Number	Model name	Model development team	Model development time	Number of entries	Specific items	Scoring method	Classification of risks	Scope of application	Sensitivity and specificity
6	Wells score [24]	Canadian scholars Wells *et al.*	1995 2003	10	Signs and symptoms of deep vein thrombosis, treatment-related risk factors, diagnosis, and medical history	Positive predictive factors are assigned 1 point, while negative predictive factors are assigned 2 points.	Patients are classified into low-risk (0 points), moderate risk (1–2 points), and high-risk (> 3 points) levels based on their cumulative scores.	Outpatient	Kappa = 0.85
7	Gynecological patient surgical venous thromboembolism risk assessment scale [23]	Wu Heyu, Affiliated Union Hospital of Tongji Medical College, Huazhong University of Science and Technology	2021	38	General information of the patient, disease and treatment-related factors, surgical-related factors, laboratory tests	Assign points based on weight	/	Surgical period for gynecological patients	After 2 rounds of consultation with 15 experts using Delphi method, the expert authority coefficient was 0.81, and the coordination coefficients of expert opinions were 0.55 and 0.58, respectively.
8	COMPASS-CAT thrombus risk assessment model [25]	French scholar Gerotziafas	2017	8	Hormone receptor-positive breast cancer receiving hormone therapy (or) treated with anthracycline drugs, the time since cancer diagnosis is ≤ 6 months, there is a central venous catheter (CVC), personal history of peripheral artery disease, ischemic stroke, coronary artery disease, hypertension, hyperlipidemia, diabetes, BMI ≥ 30, advanced tumor, recent (within 3 months) hospitalization due to acute disease, personal VTE history, platelet count ≥ 350×10^9/L	Assign scores of 1–6 based on risk factors.	/	Outpatients with breast cancer, colorectal cancer, lung cancer, or ovarian cancer	AUC is 0.85, sensitivity is 88%, and specificity is 52%.
9	Khorana risk assessment model [26]	University of Rochester Khorana, USA	2008	5	Tumor location, pre-chemotherapy platelet count, white blood cell count, hemoglobin, body mass index.	Each item is scored 0–2 points	According to the total score, patients are divided into three groups: 0 points for low-risk, 1–2 points for moderate risk, and ≥ 3 points for high-risk.	Cancer Clinic	In the deduction queue, the sensitivity is 40.0% and the specificity is 88%. In the validation queue model, the sensitivity was 35.7% and the specificity was 89.6%.
10	Chaoyang model [28]	Department of Thoracic Surgery, Beijing Chaoyang Hospital Affiliated to Capital Medical University	2018	9	Preoperative patient physical condition grading, pathology, surgical procedure, surgical time, intraoperative bleeding, D-dimer, red blood cell count, BMI, age.	Risk factors are scored 0–5 points, respectively	Clinical doctors need to remain vigilant about VTE for individuals with a score of ≥ 9.	Postoperative patients in thoracic surgery	AUC is 0.80, specificity is 91%, and sensitivity is 57%.

4. Application status of the risk assessment model for venous thromboembolism in gynecological patients

4.1. Risk assessment model for perioperative venous thromboembolism in gynecological patients

4.1.1. Application of the Caprini risk assessment model

The Caprini risk assessment model was developed by scholar Caprini from Northwestern University in the United States in 2005, with a total of 38 risk factors. The 2007 American College of Obstetricians and Gynecologists (ACOG) gynecological VTE prevention guidelines recommended this scale [9]. In 2021, the consensus development group for preventing gynecological surgical thrombosis and the Colombian Federation of Obstetrics and Gynecology released a consensus on preventing gynecological surgical thrombosis, which noted that key recommendations for implementation include the use of the Caprini scale and interventions consistent with individual perioperative risk levels [18]. The risk assessment of perioperative VTE in gynecology is often based on the modified Caprini scale published in 2010 [20]. A study in China identified 53 hospitalized patients diagnosed with DVT during gynecological malignant tumor surgery as the DVT group and 106 hospitalized patients without DVT during the same period as the control group. These findings confirm that the Caprini thrombus risk assessment model can effectively predict the risk of postoperative DVT in patients who are undergoing gynecological malignant tumor surgery [30]. Its advantage lies in the comprehensive coverage of risk factors and high sensitivity. Individualized and quantifiable VTE risk assessment strategies are simple and easy to use. The Caprini risk assessment model is widely used; however, it has certain limitations when applied to gynecological patients in China. In 2019, Chinese scholars such as Gao *et al.* [31] proposed that the risk factors in this model involve multiple disciplines. Owing to differences in race and gynecological disease characteristics between East China and West China, some projects are not suitable for gynecological patients in China. Previous studies have been revised on the basis of the characteristics of China [6,10,32,33]. Moreover, although the model has high sensitivity, its specificity needs to be further improved.

4.1.2. Application of the G-Caprini risk assessment model

The G-Caprini risk assessment model was developed by a team of obstetrics and gynecology experts in China in 2017. While writing the *Expert Consensus on Prevention of Deep Venous Thrombosis and Pulmonary Embolism after Gynecological Surgery* [6], the expert team also developed a G-Caprini risk assessment model based on the Caprini score, which consists of six items. Previous studies have evaluated the risk of DVT in 97 patients who underwent pelvic surgery within two hours after surgery and implemented corresponding graded prevention measures. The results suggest that graded interventions based on the G-Caprini model have significant clinical effects in preventing deep vein thrombosis in patients with gynecological pelvic surgery. This model can significantly reduce the occurrence of deep vein thrombosis in gynecological pelvic surgery patients, shorten their hospitalization time, and demonstrate high clinical application value [34]. The *Expert Consensus on the Prevention of Deep Venous Thrombosis and Pulmonary Embolism after Gynecological Surgery* recommends the use of the G-Caprini risk assessment model to grade the risk of DVT and pulmonary embolism in gynecological surgery patients. On the basis of the assessed risk level of patients, appropriate preventive interventions should be implemented accordingly. This risk assessment model was developed on the basis of the characteristics of gynecological surgery patients in China. Its advantage lies in combining the actual situation and cultural characteristics of Chinese patients to implement risk assessment quickly, simply, and easily for clinical application.

Its limitations are mainly manifested in its current scope of application, which is mainly for VTE prevention in gynecological postoperative patients, and reports on preoperative evaluation and intervention effects are not available. This model needs to comprehensively consider the predictive performance of VTE-related biomarkers.

4.1.3. Application of the Autar risk assessment model

The Autar risk assessment model was developed by British nursing expert Autar in 1996 [22]. The model is based on the three major factors of venous thrombosis and uses this scale to conduct nurse-led VTE risk assessment for orthopedic patients. The model includes a total of seven dimensions. In 2003, Autar revised the model to increase the impact of age, hormone replacement therapy, surgical type, and high-risk diseases such as hemolytic anemia and varicose veins on thrombosis [35]. In recent years, this model has been widely used in China. He and Chen [36], Qin *et al.* [37], and Hu [38] used the Autar risk assessment model to classify high-risk VTE patients among gynecological patients during the perioperative period, reducing the incidence of VTE and shortening the hospital stay of patients. The advantage of this model lies in its clear classification method, which proposes preventive measures under different classifications and evaluates and prevents them synchronously. A limitation of the model lies in the lack of prospective research validation. In addition, the model contains multiple factors related to orthopedics, which have high specificity for orthopedic surgery patients but relatively weak specificity for gynecological diseases. Factors related to gynecological diseases with concomitant chronic underlying diseases were not considered. Further large-scale validation is recommended for the application of this model in gynecological patients.

4.1.4. Application of the Rogers risk assessment model

The Rogers risk assessment model was developed and validated by Rogers *et al.* from Brigham and Women's Hospital at Harvard Medical School in 2007 and comprises a total of 26 items [21]. Heft *et al.* applied the Rogers risk assessment model and the Caprini risk assessment model to the gynecological patient population and compared their utility in predicting VTE in the gynecological patient population. The results showed that the Rogers risk assessment model identified 96.8% of patients as having an extremely low risk of VTE, 3.1% as having a low risk, and 0.1% as having a moderate risk. To date, the Rogers risk assessment model in China has been applied only to perioperative lung cancer patients undergoing thoracic surgery, and its results suggest that the effectiveness of VTE risk level assessment is still uncertain [39]. The advantage of this model lies in the large amount of research data used during the initial development of the model. Its limitations include the lack of prospective research validation, insufficient ease of use, and a lack of ability to distinguish differences in VTE risk. In addition, factors such as age, BMI, family history, hormone therapy, and immobilization status of VTE high-risk patients were not taken into account, which is also a potential limitation of this model [39]. The applicability of this model in gynecological patients needs to be carefully considered.

4.1.5. Application of the Padua risk assessment model

The Padua risk assessment model was developed by Barbar *et al.* from the University of Padua in Italy [27] on the basis of the Kucher scale [40]. The rating includes 11 items. The Padua risk assessment model was prospectively validated in a cohort study of 1,180 inpatients in the internal medicine ward. The incidence of VTE at 3 months was 3.1%. In this study, all patients underwent systematic screening for VTE at 3 months, and sudden death of unknown cause was not considered a VTE event. During the 3-month follow-up period, the incidence of events

in the low-risk group (Padua score < 4) was 0.3%. At present, multiple hospitals in China have applied this scale to assess the risk of VTE in internal medicine inpatients. Tong *et al.* [41] reported that preoperative scoring exhibits predictive value for VTE in patients undergoing gynecological tumor surgery. Previous studies have compared the Caprini risk assessment model with the Padua risk assessment model. Currently, for hospitalized patients in China, the Caprini risk assessment model demonstrates greater sensitivity and better predictive ability than the Padua risk assessment model [42,43]. The advantage of this model lies in its prospective validation in cohort studies, strong data support, and high credibility of its application effectiveness. Layering is simple and easy to implement. One limitation lies in the lack of inclusion of relevant factors during gynecological surgery, and the effectiveness of intraoperative and postoperative applications requires further verification. When the Padua risk assessment model is applied in gynecological patients, further revision and use of this model on the basis of the characteristics of gynecological patients are recommended.

4.1.6. Application of the Wells score

The Wells score was developed by Canadian scholar Wells in 1995 and includes two models, the Wells DVT model and the Wells PE model [24]. In 2003, the Wells score was revised [44], which included 10 risk factors. Currently, the Wells score is widely used for the diagnosis of VTE. When combined with D-dimer testing, the Wells score performs similarly to conventional radiographic imaging evaluations [31]. The Wells score + D-dimer has a high predictive value for AECOPD combined with pulmonary embolism [45] and for lung cancer combined with acute pulmonary embolism [46]. Some studies have also noted that the Wells score is not ideal for the diagnosis of suspected pulmonary embolism in hospitalized patients [47], and its predictive power for the risk of PTE in hospitalized patients with lower limb venous thrombosis is poor [48]. The advantage of this model lies in its comprehensive treatment factors, design involving disease factors, and high diagnostic value for DVT. Its limitation lies in its low predictive ability for PTE, as it does not consider factors such as the age, BMI, medical history, and surgical condition of gynecological patients. Therefore, the Wells score is highly important for the diagnosis of VTE, but its predictive performance as a risk factor for VTE occurrence is not satisfactory.

4.1.7. Application of the Postoperative Venous Thrombosis Risk Assessment Scale for Gynecological Patients

The Risk Assessment Scale for Postoperative Venous Thrombosis in Gynecological Patients [23] was developed by Wu *et al.* from the Union Hospital of Tongji Medical College, Huazhong University of Science and Technology, in 2021. The assessment scale includes four primary indicators (patient general condition, disease- and treatment-related factors, surgery-related factors, and laboratory tests), 16 secondary indicators, and 38 tertiary indicators. The weights represent the relative importance of the indicators in the scale, with items allocated according to their weights to calculate the overall risk score for postoperative venous thrombosis in gynecological patients. This model is suitable for assessing the risk of venous thrombosis in gynecological patients during surgery. The model study is based on the three elements of Virchow's thrombosis and was constructed by extensively consulting the literature, referring to relevant guidelines and commonly used clinical scales. The Delphi method was used to consult 15 experts for two rounds. The expert authority coefficient was 0.81, and the coordination coefficients of expert opinions were 0.55 and 0.58. The advantage of this model lies in its high specificity for gynecological surgery patients, which is specifically designed for assessing the risk of venous thrombosis during surgery. The content is comprehensive and scientific. One limitation is that there are currently no clinical application reports,

and sensitivity and specificity data are lacking. In the future, its clinical predictive efficacy can be further validated.

4.2. Application of a risk assessment model for venous thromboembolism during chemotherapy in gynecological cancer patients

4.2.1. Application of the COMPASS-CAT thrombosis risk assessment model

The COMPASS-CAT thrombus risk assessment model was developed by the French scholar Gerotziafas [25] in 2017 and has a total of eight items. Spyropoulos *et al.* [49] conducted external validation of the COMPASS-CAT thrombus risk assessment model using 3,814 patients with ovarian cancer, breast cancer, lung cancer, and colon cancer who met the standards. The results suggest that the model has good negative predictive value, but further prospective validation research is still needed, especially within 6 months of cancer diagnosis. The model needs to be applied in routine clinical practice for primary thrombosis prevention in cancer patients with solid tumors at high risk of VTE. In China, Tan *et al.* [50] applied the COMPASS-CAT thrombus risk assessment model to 483 patients with gynecological malignant tumors to predict the risk of venous thrombosis related to gynecological malignant tumors. The results showed that the model had a moderate level of risk prediction for VTE related to malignant gynecological tumors. The advantage of this model lies in its prospective validation, strong data support, and positive application outcomes in the field of gynecology. It is expected to become a powerful tool for predicting the risk of VTE in patients undergoing chemotherapy for gynecological tumors [51]. One limitation is that the model does not consider the surgical treatment factors of chemotherapy patients, and further revisions are needed for patients who undergo both surgical and adjuvant treatments before use.

4.2.2. Application of the Khorana risk assessment model

The Khorana risk assessment model was designed by Khorana from the University of Rochester in the United States in 2008, with a total of five items [26]. The Khorana risk assessment model was revised in 2013 and adopted by the American Society of Clinical Oncology as part of the VTE management guidelines for assessing chemotherapy-related VTE risk in outpatient patients [52]. Rushad Patell conducted a retrospective cohort study (n = 3,531) on cancer patients admitted to the Cleveland Clinic in 2017 and confirmed that the Khorana risk assessment model represents a useful risk tool for predicting venous thromboembolism in hospitalized cancer patients. However, relevant studies have shown that the Khorana evaluation model has a sensitivity of 0.78 and a specificity of 0.48, both of which are not ideal [28]. A retrospective case-control study was conducted on 221 hospitalized cancer patients admitted to a comprehensive hospital in China, and the risk of VTE in hospitalized cancer patients was stratified. The Caprini risk assessment model was more effective than the Khorana risk assessment model in identifying hospitalized cancer patients at risk of VTE [53]. The advantage of this model lies in its prospective observational study and validation using derived cohorts, with strong data support. As a tool for assessing thrombus risk in gynecological patients before chemotherapy, it can more effectively identify short-term risks of symptomatic VTE. One limitation is that, to fully account for other factors associated with chronic diseases, the current application of risk stratification is not ideal, resulting in relatively low effectiveness for long-term risk prediction.

4.3. Other risk assessment models for venous thromboembolism in gynecological patients

The Chaoyang model [28] was developed by the Department of Thoracic Surgery at Beijing Chaoyang Hospital, affiliated with Capital Medical University, in 2018 and comprises a total of nine risk factors. A single-center

retrospective study was conducted on 533 patients who underwent surgical treatment from July 2016 to December 2017. After verification, the Chaoyang model demonstrated sufficient ability to identify patients at different risks of VTE events. Moreover, the model is to some extent superior to the Caprini model. This study demonstrated that the Chaoyang model can be used to predict the occurrence of VTE in thoracic surgery patients in China. The advantage of this model is that it is a localized risk prediction tool tailored to China's national conditions and is supported by a large amount of retrospective data. Its limitations lie in the fact that the study was only conducted in a single center, which limits its practicality and dissemination. Moreover, prospective research validation is lacking. This model needs further validation in large, multicenter, retrospective studies that account for the unique characteristics of gynecological patients. It is expected to provide valuable insights for assessing the risk of postoperative venous thromboembolism in gynecology.

5. Comparative analysis of risk assessment models for venous thromboembolism in gynecological patients

5.1. Comparison of evaluation contents among various models

In terms of evaluation content, each model focuses on high-risk disease factors, which mainly include tumor factors and diseases of the circulatory, digestive, and respiratory systems, with different emphases. Only the Caprini risk assessment model and the gynecological patient surgical venous thrombosis risk assessment scale included family history factors. As a factor influencing VTE, the extent of family history's impact on the incidence of VTE requires further investigation. Regarding central venous access, the Caprini, G-Caprini, and COMPASS-CAT thrombus risk assessment models provide detailed scoring, whereas other models include this factor to a lesser extent. The inclusion of this factor in the assessment model is closely related to the necessity of establishing central venous access during the treatment process. With respect to pregnancy and childbirth factors, the Caprini, G-Caprini, Autar risk assessment model, and the gynecological surgical venous thrombosis risk assessment scale include this metric. It is unclear whether incorporating this factor into the gynecological VTE assessment model can reasonably improve existing models.

5.2. Comparison of the clinical validation of various models

In terms of the design of each model validation, the Caprini, COMPASS-CAT, Khorana, and Padua risk assessment models adopted prospective study designs, whereas the remainder were retrospective studies. To improve predictive ability, relevant prospective studies can be conducted on research design models for retrospective validation. Moreover, the COMPASS-CAT thrombus risk assessment model overcomes the geographical limitations of single-center surveys through multicenter, prospective follow-up. The models involved in this study have been validated using large sample data, with the exception of the gynecological patient intraoperative venous thrombosis risk assessment scale, which has not been validated with a large sample.

5.3. Comparison of the evaluation objects of various models

In terms of targeted risk assessment for venous thromboembolism in gynecological patients, the G-Caprini risk assessment model and the gynecological surgical venous thromboembolism risk assessment scale are specialized models for assessing the risk of venous thromboembolism in gynecological patients, whereas the remainder of the models are universal models. A specialized model can fully consider the patient's basic characteristics and evaluate

the patient accurately and comprehensively; universal models are generally stable and beneficial for comparing different diseases.

5.4. Comparison of hazard stratification among different models

With respect to the risk stratification of venous thromboembolism in gynecological patients using various models, currently, the surgical venous thromboembolism risk assessment scale for gynecological patients calculates a risk score on the basis of weight, and risk stratification is not currently available. Further determination of stratification values is needed in clinical practice. The COMPASS-CAT thrombus risk assessment model divides patients into two groups on the basis of clinical practice in China: the low-risk group and the high-risk group. Whether it is necessary to separate the low-risk group needs further verification. The Chaoyang model uses a cutoff score of 9, and individuals with scores ≥ 9 need to be vigilant about VTE. There have been no further reports on the applicability of the stratification criteria of this model; other models have clear risk stratification. Among these models, the Caprini risk assessment model and the Autar risk assessment model recommend different preventive measures on the basis of risk stratification, with more detailed content and greater value in guiding prevention practices.

5.5. Comparison of the application effects of various models

In terms of the effects of applying various models to gynecological patients, the Caprini risk assessment model has the highest international recognition, and the G-Caprini risk assessment model derived from this model also has high application value. The COMPASS-CAT thrombus risk assessment model has achieved ideal application results both domestically and internationally. The application effects of the Autar risk assessment model, the Rogers risk assessment model, the Wells score, the Khorana risk assessment model, and the Padua risk assessment model are average and require further verification. The domestically designed and developed gynecological patient intraoperative venous thrombosis risk assessment scale and the Chaoyang model currently have no data based on their application in China, and their clinical predictive efficacy is worth assessing.

6. Conclusion

The specific characteristics of gynecological diseases make VTE risk assessment targeted. Research on VTE risk assessment models has been conducted in foreign countries, and there have been numerous confirmed studies on risk assessment models for venous thromboembolism in gynecological patients. Currently, a few domestically designed and developed risk assessment models are available. The effectiveness of the improved foreign VTE risk assessment model still requires verification owing to differences in race, physique, lifestyle, and other aspects. To fully account for the attributes of female roles in risk assessment models, risk factor stratification should be followed by the implementation of appropriate preventive measures to enhance the model's practical guidance. In terms of research design, prospective studies should be prioritized, allowing for better planning and collecting data, thus addressing the problem of incomplete and homogeneous data often noted in retrospective studies and ultimately improving research quality. The development and applicability of a risk assessment model for venous thromboembolism in gynecological patients can serve as a future research direction. Prospective study designs should be considered, and further prospective validation is needed to confirm the performance of the model. Moreover, given the rapid development of medical information systems, the risk assessment model for venous

thromboembolism in gynecological patients can be included as part of the hospital management HIS system according to the implementation rules of the assessment, forming a specialized medical tool for the diagnosis of venous thromboembolism in gynecological patients. Multicenter cloud data facilitates interoperability and sharing, overcomes geographical limitations, and provides real and referenceable data for reducing venous thromboembolism in gynecological patients, effectively achieving multichannel quality control.

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The authors declare no conflict of interest.

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References

[1] Bang SM, Jang MJ, Oh D, et al., 2010, Korean Guidelines for the Prevention of Venous Thromboembolism. J Korean Med Sci, 25(11): 1553–1559.

[2] Cantrell LA, Garcia, C, Maitland HS, 2018, Thrombosis and Thromboprophylaxis in Gynecology Surgery. Clin Obstet Gynecol, 61(2): 269–277.

[3] Ratib S, Walker AJ, Card TR, et al., 2016, Risk of Venous Thromboembolism in Hospitalised Cancer Patients in England—A Cohort Study. J Hematol Oncol, 9(1): 60.

[4] Falck-Ytter Y, Francis CW, Johanson NA, et al., 2012, Prevention of VTE in Orthopedic Surgery Patients: Antithrombotic Therapy and Prevention of Thrombosis, 9th ed: American College of Chest Physicians Evidence-Based Clinical Practice Guidelines. Chest, 141(2 Suppl): e278S–e325S.

[5] Hill J, Treasure T, 2010, Reducing the Risk of Venous Thromboembolism in Patients Admitted to Hospital: Summary of NICE Guidance. BMJ, 340: c95.

[6] Lang J, Wang C, Qu H, et al., 2017, Expert Consensus on the Prevention of Deep Vein Thrombosis and Pulmonary Embolism After Gynecological Surgery. Chinese Journal of Obstetrics and Gynecology, 52(10): 649–653.

[7] Romano F, Di Lorenzo G, Stabile G, et al., 2022, A Systematic Review of the Guidelines on Venous Thromboembolism Prophylaxis in Gynecologic Oncology. Cancers (Basel), 14(10): 2439.

[8] Li T, Li C, Geng Q, et al., 2019, Research Progress on Risk Assessment Tools for Venous Thromboembolism. Chinese Journal of Modern Nursing, 25(35): 4657–4661.

[9] ACOG, 2007, Practice Bulletin No. 84: Prevention of Deep Vein Thrombosis and Pulmonary Embolism. Obstet Gynecol, 110(2 Pt 1): 429–440.

[10] Qu H, Li Z, Zhai Z, et al., 2015, Predicting of Venous Thromboembolism for Patients Undergoing Gynecological Surgery. Medicine (Baltimore), 94(39): e1653.

[11] Xu Y, Jia Y, Zhang Q, et al., 2021, Incidence and Risk Factors for Postoperative Venous Thromboembolism in Patients with Ovarian Cancer: Systematic Review and Meta-Analysis. Gynecol Oncol, 160(2): 610–618.

[12] Che Y, 2018, The Current Status of Research on the Incidence of Venous Thromboembolism in Obstetrics and Gynecology in China. Chinese Journal of Practical Gynecology and Obstetrics, 34(7): 709–713.

[13] Tasaka N, Minaguchi T, Hosokawa Y, et al., 2020, Prevalence of Venous Thromboembolism at Pretreatment Screening and Associated Risk Factors in 2086 Patients with Gynecological Cancer. J Obstet Gynaecol Res, 46(5): 765–773.

[14] Ma SG, Hu J, Huang Y, 2020, The Risk Factors for Perioperative Venous Thromboembolism in Patients with Gynecological Malignancies: A Meta-Analysis. Thromb Res, 196: 325–334.

[15] Tong T, Yin X, Gao H, 2021, Analysis of the Main Risk Factors for Gynecological Perioperative Venous Thromboembolism. Chinese Medical Journal, 56(5): 566–569.

[16] Yang T, Tian S, Wang Y, et al., 2019, Evaluation of Risk Factors for Venous Thromboembolism in Patients Who Underwent Gynecological Surgery and Validation of a Fast-Rating Assessment Table. Med Sci Monit, 25: 8814–8819.

[17] Tian Q, Li M, 2021, Risk Factors of Deep Vein Thrombosis of Lower Extremity in Patients Undergone Gynecological Laparoscopic Surgery: What Should We Care. BMC Women's Health, 21(1): 130.

[18] Grupo Desarrollador Del Consenso De Tromboprofilaxis En Cirugia Ginecologica 1, Federacion Colombiana de Obstetricia Y Ginecologia Fecolsog, 2021, Consensus on Thromboprophylaxis in Gynecological Surgery. Rev Colomb Obstet Ginecol, 72(1): 53–68.

[19] Gialeraki A, Valsami S, Pittaras T, et al., 2018, Oral Contraceptives and HRT Risk of Thrombosis. Clin Appl Thromb Hemost, 24(2): 217–225.

[20] Caprini JA, 2010, Risk Assessment as a Guide for the Prevention of the Many Faces of Venous Thromboembolism. Am J Surg, 199(1 Suppl): S3–10.

[21] Rogers SO Jr, Kilaru RK, Hosokawa P, et al., 2007, Multivariable Predictors of Postoperative Venous Thromboembolic Events After General and Vascular Surgery: Results from the Patient Safety in Surgery Study. J Am Coll Surg, 204(6): 1211–1221.

[22] Autar R, 1996, Nursing Assessment of Clients at Risk of Deep Vein Thrombosis (DVT): the Autar DVT scale. J Adv Nurs, 23(4): 763–770.

[23] Wu H, Chu J, Cui L, 2021, Construction of a Risk Assessment Scale for Postoperative Venous Thrombosis in Gynecological Patients. Journal of Nursing, 36(1): 47–49.

[24] Wells PS, Hirsh J, Anderson DR, et al., 1995, Accuracy of Clinical Assessment of Deep-Vein Thrombosis. Lancet, 345(8961): 1326–1330.

[25] Gerotziafas GT, Taher A, Abdel-Razeq H, et al., 2017, A Predictive Score for Thrombosis Associated with Breast, Colorectal, Lung, or Ovarian Cancer: The Prospective COMPASS-Cancer-Associated Thrombosis Study. Oncologist, 22(10): 1222–1231.

[26] Khorana AA, Kuderer NM, Culakova E, et al., 2008, Development and Validation of a Predictive Model for Chemotherapy-Associated Thrombosis. Blood, 111(10): 4902–4907.

[27] Barbar S, Noventa F, Rossetto V, et al., 2010, A Risk Assessment Model for the Identification of Hospitalized Medical Patients at Risk for Venous Thromboembolism: the Padua Prediction Score. J Thromb Haemost, 8(11): 2450–2457.

[28] Tian B, Li H, Cui S, et al., 2019, A Novel Risk Assessment Model for Venous Thromboembolism After Major Thoracic Surgery: A Chinese Single-Center Study. J Thorac Dis, 11(5): 1903–1910.

[29] Liu Q, Zhang K, Liu H, et al., 2022, Comparison of Clinical Value of Different Thrombus Risk Assessment Models in Predicting Postoperative Deep Vein Thrombosis in Patients Undergoing Hysteroscopic Myomectomy. Journal of Xinxiang Medical College, 39(1): 19–24.

[30] Lou Y, Shen Y, 2017, The Effectiveness of Caprini Thrombus Risk Assessment Model in Predicting the Risk of DVT in Patients Undergoing Gynecological Malignant Tumor Surgery. Journal of Southeast University (Medical Edition), 36(3): 333–337.

[31] Gao H, Wang J, Tong T, 2019, Risk Assessment Process and Clinical Practice Management of Gynecological Venous Thromboembolism. Chinese General Practice, 22(12): 1385–1391.

[32] Di P, Liang Z, Xu L, et al., 2016, Study on the Risk Factors of Thrombosis in Patients with Venous Thromboembolism and Cerebral Infarction. Thrombosis and Hemostasis, 22(6): 630–632.

[33] Zhao Y, Wang S, Kong G, et al., 2013, Diabetes and Venous Thromboembolism. Chinese. Journal of Joint Surgery (Electronic Edition), 7(3): 393–396.

[34] Zou D, Zhang W, Xu X, 2020, Observation of the Effect of Graded Intervention based on G-Caprini Model on Preventing Deep Vein Thrombosis in Patients After Gynecological Pelvic Surgery. Internal Medicine, 15(4): 488–489, 492.

[35] Autar R, 2003, The Management of Deep Vein Thrombosis: The Autar DVT Risk Assessment Scale Re-Visited. Journal of Orthopaedic Nursing, 7(3): 114–124.

[36] He C, Chen X, 2016, Research on the Prevention of Lower Limb Deep Venous Thrombosis in Gynecological Surgery Patients through Nursing Intervention Based on Aurar Scale. Journal of Practical Clinical Medicine, 20(22): 113–115.

[37] Qin Y, Wang L, Xu R, et al., 2020, The Application of Autar Assessment Scale in Preventing Deep Vein Thrombosis in Cervical Cancer Patients. General Nursing, 18(19): 2381–2383.

[38] Hu J, 2020, Application of Autar Thrombosis Risk Assessment Scale in Preventing Postoperative Deep Venous Thrombosis in Patients with Gynecological Malignant Tumors. Practical Clinical Nursing Electronic Journal, 5(21): 36.

[39] Guo H, Fang Q, Huang J, et al., 2019, Validation Study of Caprini and Rogers Thrombus Risk Assessment Model in Perioperative Lung Cancer Patients Undergoing Thoracic Surgery? Tumor Prevention and Treatment, 32(8): 660–667.

[40] Kucher N, Koo S, Quiroz R, et al., 2005, Electronic Alerts to Prevent Venous Thromboembolism among Hospitalized Patients. N Engl J Med, 352(10): 969–977.

[41] Tong T, Gao H, Sun T, 2018, Comparative Study on the Predictive Value of Four Common Risk Assessment Models for Postoperative Venous Thromboembolism in Patients with Gynecological Malignancies Practical. Journal of Cardiovascular and Cerebrovascular Diseases, 26(7): 94–98.

[42] Chen X, Pan L, Deng H, et al., 2018, Risk Assessment in Chinese Hospitalized Patients Comparing the Padua and Caprini Scoring Algorithms. Clin Appl Thromb Hemost, 24(9_suppl): 127s–135s.

[43] Zhou H, Hu Y, Li X, et al., 2018, Assessment of the Risk of Venous Thromboembolism in Medical Inpatients using the Padua Prediction Score and Caprini Risk Assessment Model. J Atheroscler Thromb, 25(11): 1091–1104.

[44] Wells PS, Anderson DR, Rodger M, et al., 2003, Evaluation of D-Dimer in the Diagnosis of Suspected Deep-Vein Thrombosis. N Engl J Med, 349(13): 1227–1235.

[45] Cheng Z, Yang M, Zhang Z, et al., 2018, The Predictive Value of Wells Score, Modified Geneva Score Combined with

D-Dimer for the Risk of Acute Exacerbation of Chronic Obstructive Pulmonary Disease Complicated with Pulmonary Embolism. Chinese Journal of Medicine, 98(48): 3925–3929.

[46] Wang S, Chen W, Li J, et al., 2021, The Predictive Value of D-Dimer Combined with Wells Score Correction for Lung Cancer Complicated with Acute Pulmonary Embolism. Hebei Medical, 27(12): 2023–2027.

[47] Liu J, Sun L, Xiang H, et al., 2021, A Comparative Study of the Diagnostic Value of Wells Score, Geneva Score, and YEARS Method in Hospitalized Patients with Suspected Pulmonary Embolism. Journal of Interventional Radiology, 30(6): 552–556.

[48] Xi M, Luo D, Zhou R, et al., 2020, Wells Score and Related Risk Factors Analysis in Patients with Lower Limb Venous Thrombosis. Chinese Medicine, 15(7): 1058–1062.

[49] Spyropoulos AC, Eldredge JB, Anand LN, et al., 2020, External Validation of a Venous Thromboembolic Risk Score for Cancer Outpatients with Solid Tumors: The COMPASS-CAT Venous Thromboembolism Risk Assessment Model. Oncologist, 25(7): e1083–e1090.

[50] Tan K, Liu D, Liu H, et al., 2021, The COMPASS-CAT Model for Predicting the Risk of Venous Thrombosis Associated with Gynecological Malignant Tumors. Chinese General Practice, 19(12): 2132–2135, 2140.

[51] Zhang J, Zhang Y, 2021, The Current Research Status of Risk Assessment Models for Venous Thromboembolism in Obstetrics and Gynecology Patients. Chinese Journal of Maternal and Child Clinical Medicine (electronic version), 17(1): 15–22.

[52] Lyman GH, Khorana AA, Kuderer NM, et al., 2013, Venous Thromboembolism Prophylaxis and Treatment in Patients with Cancer: American Society of Clinical Oncology Clinical Practice Guideline Update. J Clin Oncol, 31(17): 2189–2204.

[53] Hu Y, Li X, Zhou H, et al., 2020, Comparison between the Khorana Prediction Score and Caprini Risk Assessment Models for Assessing the Risk of Venous Thromboembolism in Hospitalized Patients with Cancer: A Retrospective Case Control Study. Interact Cardiovasc Thorac Surg, 31(4): 454–460.