Compared with nonpregnant women, pregnancy carries a four- to fivefold higher risk of venous thromboembolism (VTE). Despite increasing use of heparin prophylaxis in identified high-risk patients, pulmonary embolism still is the leading cause of maternal mortality in the western world. However, evidence on optimal use of thromboprophylaxis is scarce. Thrombophilia, the hereditary or acquired tendency to develop VTE, is also thought to be associated with complications in pregnancy, such as recurrent miscarriage and preeclampsia. In this review, the current evidence on optimal thromboprophylaxis in pregnancy is discussed, focusing primarily on VTE prevention strategies but also discussing the potential to prevent recurrent pregnancy complications with heparin in pregnant women with thrombophilia.
in pregnancy occurs more proximal and more often in the left leg. A review in 2010 observed 71% isolated proximal DVTs without manifestation in the distal veins and a proportion of 17% of isolated iliac vein thrombosis during pregnancy. Importantly, isolated proximal DVT (i.e., without involvement of the calf veins) is common during pregnancy and is important for diagnostic considerations. Since pregnancy-related DVT occurs at a young age, and because of the proximal location of many of these DVTs, long-term consequences are very common. If postthrombotic syndrome complicates the clinical course, this has a very negative impact on quality of life. The impact on quality of life depends on the severity of the postthrombotic syndrome. Fortunately, severe postthrombotic syndrome is a rare condition but still occurs in up to approximately 7% of pregnancy-related VTE.

**Pregnancy-Related Physiological Changes to Coagulation Factors**

Virchow's classic triad for VTE—hypercoagulability, venous stasis, and vascular damage—occurs in an uncomplicated course of pregnancy and delivery.

During pregnancy, the body is exposed to major hemodynamic and hemostatic changes that result in a procoagulant state. In response to a higher bleeding risk in pregnancy and especially during delivery and the early puerperium period, the body shifts to a hypercoagulable state: plasma levels of procoagulant factors are elevated (such as coagulant factors VII, VIII, X, fibrinogen, and von Willebrand factor) and anticoagulant activity decreases with a resulting physiological inhibitor deficiency (reduced levels of protein S and acquired resistance to activated protein C). Furthermore, the activity of the fibrinolytic system is reduced due to decreased activity of tissue plasminogen activator as well as increased levels of plasminogen activator inhibitors. Moreover, hemodynamic changes (namely, progesterone-induced vasodilatation, mechanical compression of inferior vena cava and iliac veins by the enlarging gravid uterus) and delivery or venous hypertension-associated vascular injury contribute to the increased risk of VTE.

**Personal History of Venous Thromboembolism**

Likely the strongest individual risk factor for women experiencing pregnancy-related VTE is a personal history of DVT and/or PE. Pregnant women with previous venous thrombosis are at a 3.5-fold higher risk to suffer from VTE recurrence during pregnancy than outside the pregnancy with an estimated absolute risk of recurrence of 6 to 10% if no heparin thromboprophylaxis is applied.

The circumstances and number of previous VTE influence the VTE recurrence risk during pregnancy and puerperium. Previous VTE events associated with hormone treatment or previous pregnancies are associated with a higher risk of recurrence in a subsequent pregnancy than prior VTE events that were unprovoked or provoked by transient, non-hormone-related risk factors (i.e., trauma, surgery, immobility). De Stefano et al. performed a retrospective cohort analysis in 1,104 women with prior single DVT or isolated PE to evaluate the VTE recurrence risk during pregnancy and puerperium without antithrombotic prophylaxis. They identified 155 pregnancies and 120 postnatal periods without thromboprophylactic intervention. In women with a previously unprovoked VTE or a VTE related to pregnancy or oral contraceptive use, the VTE recurrence rate was 7.5% (95% confidence interval [CI]: 4.0–13.7). In contrast, if the index VTE was neither unprovoked, nor related to pregnancy and not associated with oral contraceptive use, no recurrences of VTE during pregnancy were observed. During puerperium, risks of recurrent VTE were 15.5% in women with a pregnancy-related prior VTE (95% CI: 7.7–28.7); 7.1% (95% CI: 1.9–22.6) in the group with nonhormonal transient risk factors and 3.1% (95% CI: 0.5–15.7) in women with a prior unprovoked VTE. Thus, recurrence risk was nearly fourfold elevated in women who experienced a first pregnancy-associated VTE. The risk of recurrence is also elevated in pregnancies following a previously unprovoked VTE.

**Individual Risk Factors for Venous Thromboembolism**

Besides the direct pregnancy-related anatomical and hemostatic changes and the impact of a previous VTE, several additional individual factors enhance the risk for VTE in pregnancy. Risk factors for VTE in pregnancy include anthropometric characteristics, acute or chronic illness, as well as pregnancy-related and obstetric complications.

For example, obesity with pre-pregnancy body mass index (BMI) greater than 30 kg/m² is associated with elevated VTE risk in pregnancy (adjusted OR: 9.7; 95% CI: 3.1–30.8) and postpartum (adjusted OR: 2.8; 95% CI: 0.8–9.8). Blom- don et al. considered the pre-pregnancy BMI as appropriate tool with a linear association regarding the postpartum VTE risk. The highest risk was found in severely obese women with increased postpartum VTE risk up to fourfold (pre-pregnancy BMI ≥40 kg/m²; OR: 4.0 (95% CI: 2.7–6.3).

Furthermore, immobilization of more than 7 days, especially in combination with obesity and hospital admission, is a relevant risk factor. Ovarian stimulation for in vitro fertilization doubles VTE risk, but the absolute risk is low (0.1–0.3% per approach). However, women with severe ovarian hyperstimulation syndrome (OHSS) are at a substantially increased risk (up to 100-fold relative risk; absolute risk: 1–4%) of developing VTE events.

Caesarean section is associated with two- to fourfold increase of thromboembolic risk, which translates to an average of 3 VTEs out of 1,000 performed interventions and depends on several issues: elective C-section has a lower VTE risk in comparison to emergency caesarean sections. Currently, there are no universally accepted validated risk scores. There are only few scores with limited validity for individual risk stratification in pregnancy and puerperium.
The Royal College of Obstetricians and Gynaecologists (RCOG) guideline recommends a risk score considering preexisting risk factors (i.e., previous provoked VTE, known high-risk thrombophilia, relevant comorbidities, family history in first-degree relative of unprovoked or estrogen-related VTE, low-risk thrombophilia, age, obesity, and more), obstetric risk factors (like preeclampsia in current pregnancy, in vitro fertilization, caesarean section in labor, elective C-section, prolonged labor, and more), and transient risk factors (i.e., OHSS, any surgical interventions, current...
systemic infection, immobility, dehydration, and additional factors).\textsuperscript{37} If the score exceeds 3 points, one should consider thromboprophylaxis from the first trimester. If the score is 3 points, considering thromboprophylaxis from 28 weeks is recommended and if the score is at least 2 points, postnatal thromboprophylaxis for at least 10 days should be considered.

Hereditary Thrombophilia

Known thrombophilia increases VTE recurrence risk in pregnant women (~Table 2). Inherited thrombophilia is present in up to half of the cases of pregnancy-associated VTE. The most common inherited genetic risk factors for thrombophilia in the European population are the heterozygous forms of the factor V Leiden and prothrombin 20210 gene mutation, with prevalences of approximately 5 and 2% of healthy subjects, respectively.\textsuperscript{11} In women who suffered from DVT or PE in pregnancy or puerperium, these genetic disorders can be found much more frequently. In women with or without a positive history for VTE during pregnancy and postpartum, Gerhardt et al reported in 2016 prevalences of 28% for heterozygous factor V Leiden, 8% for heterozygous prothrombin polymorphism G20210A, 2.6% for homozygous factor V Leiden, and 8% for compound heterozygous factor V Leiden/heterozygous prothrombin mutations.\textsuperscript{38}

Similar to the impact of hereditary thrombophilia outside of pregnancy, type of genetic defects and penetrance in the family history of the associated VTE risks vary considerably in pregnant women. For instance, homozygous factor V Leiden has been shown to increase the relative VTE risk by a factor of 35, whereas heterozygous factor V Leiden carried an eightfold risk increase\textsuperscript{39} with compound defects somewhere in between.\textsuperscript{38,40} Considering a baseline incidence of VTE of 1 per 1,000 in pregnant women, the absolute risk remains moderate with 3.4 and 0.8%,\textsuperscript{38,40,41} but, in the presence of additional risk factors, the combined risk may be further increased.

Other thrombophilias are protein C or S deficiency or antithrombin deficiency. Such defects are quite rare in the general population with overall prevalence of 0.2%, 0.03 to 0.13%, or 0.02%, respectively.\textsuperscript{42} The absolute risk for women with protein C or S deficiency to develop VTE during pregnancy seems to depend on the presence of family history of VTE. Women with coagulation inhibitor deficiency of protein C or S without a personal or family history of VTE are reported to present ante- or postpartum VTE incidences of 0.7% (95% CI: 0.3–1.5) and 0.5 (95% CI: 0.2–1.0), respectively.\textsuperscript{38} In contrast, in pregnant women with protein C or S deficiency and a family history for VTE, ante- or postpartum VTE incidences raise to 1.7 (95% CI: 0.4–8.9) and 6.6% (95% CI: 2.2–14.7), respectively.\textsuperscript{11}

### Table 2

<table>
<thead>
<tr>
<th>Hereditary thrombophilic defect</th>
<th>Incidence in general population</th>
<th>Estimated RR in pregnancy OR (95%CI)</th>
<th>Absolute risk of VTE, 1% of pregnancies (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heterozygous FVL</td>
<td>2.0–7.0</td>
<td>8.3 (5.4–12.7)</td>
<td>3.1 (2.1–4.6) 1.2 (0.8–1.8) 1.9 (0.8–2.6)</td>
</tr>
<tr>
<td>Homozygous FVL</td>
<td>0.2–0.5</td>
<td>34.4 (9.9–120)</td>
<td>14.0 (6.3–25.8) 4.8 (1.4–16.8) 6.0 (3.2–11.2)</td>
</tr>
<tr>
<td>Heterozygous PGM</td>
<td>2.0</td>
<td>6.8 (2.5–18.8)</td>
<td>2.6 (0.9–5.6) 1.0 (0.3–2.6) 1.5 (0.8–2.6)</td>
</tr>
<tr>
<td>Homozygous PGM</td>
<td>Very rare</td>
<td>26.4 (1.2–559)</td>
<td>– 3.7 (0.2–7.8) 3.0 (0.2–7.4) 6.0 (0.3–12.4)</td>
</tr>
<tr>
<td>AT deficiency\textsuperscript{2}</td>
<td>&lt;0.1–0.6</td>
<td>4.7 (1.3–17)</td>
<td>3.0 (0.8–15.8) 0.7 (0.2–2.4) 1.5 (0.3–3.2)</td>
</tr>
<tr>
<td>Protein C deficiency\textsuperscript{3}</td>
<td>0.2–0.3</td>
<td>4.8 (2.2–10.6)</td>
<td>1.7 (0.4–8.9) 0.7 (0.3–1.5) 1.5 (0.3–2.5)</td>
</tr>
<tr>
<td>Protein S deficiency\textsuperscript{4}</td>
<td>&lt;0.1–0.1</td>
<td>3.2 (1.5–6.9)</td>
<td>6.6 (2.2–14.7) 0.5 (0.2–1.0) 1.5 (0.5–2.1)</td>
</tr>
</tbody>
</table>

Abbreviations: AT, antithrombin; BMI, body mass index; CI, confidence interval; OR, odds ratio; VTE, venous thromboembolism.

\textsuperscript{2}Estimation from multiplying the baseline risk of 0.14% pregnancies by the RR in non-family studies (observed in family studies).

\textsuperscript{3}Dependent on the extent and type of AT deficiency up to ~50-fold increased risk.

\textsuperscript{4}Protein S, protein C, and AT deficiency is considered high risk by RCOG\textsuperscript{37} and GTH\textsuperscript{11} in case of severe deficiency (PC activity < 50%, PS activity < 40%, AT activity < 60%). AT deficiency is considered high risk additionally by ACOG\textsuperscript{66} and SCOG.\textsuperscript{33} All the data are derived from Hart et al.\textsuperscript{11}

### Acquired Thrombophilia

Antiphospholipid syndrome (APS) is a thrombophilic disorder that is not inherited and can occur later in life,
sometimes, but not necessarily in context with rheumatologic diseases such as systemic lupus erythematoses. The diagnosis of APS requires the detection of persisting antibodies in combination with clinical criteria such as vascular thrombosis (arterial or venous) and/or specific pregnancy complications (e.g., recurrent miscarriage, intrauterine fetal death, and preeclampsia). APS is a very heterogeneous syndrome, with risk of thrombosis varying with clinical manifestations and the number, types, and titers of the antibodies.\(^43,44\) In the absence of clinical criteria, the relevance of APS antibodies is much less clear, as these antibodies also occur in the healthy population. The prevalence of DVT and PE in APS is 39 and 14% outside of pregnancy and puerperium, respectively.\(^45\) And although prospectively collected data on the VTE risk of APS in pregnant women are scarce, there is no reason to believe that the combination of procoagulant APS antibodies and physiologic prothrombotic changes in pregnancy is not associated with an excess risk for antenatal or postnatal VTE. In fact, the incidence of VTE up to 6/1,000 women-years has been reported for women with recurrent miscarriage and APS,\(^46\) and the risk of VTE was associated with an OR of 15.8 (95% CI: 10.9–22.8) in APS patients during pregnancy.\(^47\)

However, since APS patients with a history of VTE are anticoagulated before pregnancy, they are usually treated with therapeutic doses of low-molecular-weight heparin (LMWH) during pregnancy so that the concept of thromboprophylaxis does not apply here. For the diagnosis of obstetric APS, the occurrence of thrombosis is not mandatory, since this diagnosis is commonly based on previous placenta-mediated complications or fetal loss. Obstetric manifestations like early miscarriage (before 10 weeks of gestation), late fetal loss (after 10 weeks of gestation), and premature birth among live births occur in 35, 17, and 11% in APS, respectively, as well as preeclampsia (10%) and eclampsia (4%).\(^45\) A detailed discussion of the management of obstetric APS is beyond the focus of this review, but some insights are provided below.

### VTE Risk Assessment and Evaluation for Type of Thromboprophylaxis

General considerations regarding pharmacological intervention in pregnancy address the efficacy, that is, reduction of maternal VTE risk, the maternal risk of side effects, such as inducing bleeding, local skin reactions, and fetal safety, all being crucial aspects for decision making. Antithrombotic medication can be considered safe and beneficial only when the number of prevented VTE significantly outweighs the expected harms such as bleeding complications. This balance is made more difficult by the fact that each VTE that is not prevented will lead to therapeutic anticoagulation which in turn will increase the bleeding risk much more than a primary prevention strategy with prophylactic doses of anticoagulants.

In pregnant and breastfeeding women, the agent of choice for VTE prevention and treatment is LMWH, with unfractionated heparin (UFH), danaparoid, and fondaparinux being alternatives if LMWH is contraindicated. Vitamin K antagonists are usually not used during pregnancy for thromboprophylaxis. Direct oral anticoagulants are not allowed during pregnancy, as these small molecules pass the placenta and data on fetal safety are very scarce.\(^48\) The preference of LMWH is explained by the fact that it does not cross the placenta barrier, and LMWH passes into breast milk in only very small amount that is clinically irrelevant because the bioavailability of oral heparin is sparse.\(^32\) Compared with UFH, LMWH carries lower risks for bleeding, allergies, heparin-induced thrombocytopenia, or osteoporosis.\(^49\) Moreover, monitoring of drug levels or anticoagulant effect is usually not necessary for prophylactic LMWH and due to longer half-life, once daily dosing is sufficient to achieve adequate plasma levels. Data derived from the nonpregnant population demonstrate a similar clinical efficacy and superior safety profile of LMWH versus UFH and vitamin K antagonist,\(^50,51\) which are supported by observational studies in a population of pregnant women.\(^52–55\) Thus, administration of LMWH rather than UFH is more convenient and feasible and as a consequence, LMWHs have been successfully used in pregnant women for nearly two decades now.

Nonrandomized observational data assume that pharmacological VTE prophylaxis in pregnancy and puerperium is associated with a relative VTE risk reduction comparable with other high-risk situations like extended LMWH prophylaxis after major orthopaedic surgery.\(^49,56,57\) Nevertheless, it is a crucial issue to identify pregnant and postpartum women according to their individual risk level to maximize therapeutic success in preventing VTE events and minimizing harms of side effects of thromboprophylaxis (\(\sim\) Fig. 2).

Thus, several consensus recommendations suggest to consider thromboprophylaxis only when the absolute VTE risk of a specific patient exceeds 1 to 5%\(^14,33\) (\(\sim\) Table 2). The broad range is a result from diverging thrombotic risks in pregnancy (5–10-fold increase in comparison to age-matched women) versus puerperium (15–35-fold risk increase per day). As such, in the absence of a VTE history or additional predisposing factors, the presence of a nonsevere thrombophilia such as heterozygous F-V mutation alone does usually not require a LMWH prophylaxis. However, in case of a severe thrombophilia or a combination of nonsevere thrombophilias with immobilization, severe obesity, increasing maternal age, or with a personal or familial history of VTE, this risk threshold may be surpassed, making a benefit from LMWH prophylaxis much more likely. On the other hand, the risk of bleeding must be counter balanced. In a review in 2013 including 18 studies with a total of 981 women (predominantly treated with LMWH), the risk of severe maternal bleeding in women receiving VTE treatment with therapeutic heparins was estimated to be 1.4% (95% CI: 0.60–2.41) antenatally and 1.9% (95% CI: 0.80–3.60) within 24 hours after birth.\(^58\) A retrospective observational cohort study was published by Cox et al reporting bleeding events in 172 women who received thromboprophylaxis with 40 mg enoxaparin once daily in 94.8% of the pregnancies.\(^59\) Of all deliveries, postpartum hemorrhage was reported in 36.6% (blood loss: \(\geq\)500 mL) and in 9.3% (blood loss \(\geq\)1,000 mL),

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\(^{14}\) Adapted from Eichler et al. \(^{32}\) And although prospectively collected data on the VTE risk of APS in pregnant women are scarce, there is no reason to believe that the combination of procoagulant APS antibodies and physiologic prothrombotic changes in pregnancy is not associated with an excess risk for antenatal or postnatal VTE. In fact, the incidence of VTE up to 6/1,000 women-years has been reported for women with recurrent miscarriage and APS,\(^46\) and the risk of VTE was associated with an OR of 15.8 (95% CI: 10.9–22.8) in APS patients during pregnancy.\(^47\)

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respectively, with the majority of events due to emergency caesarean sections. Four patients needed to be transfused. A systematic review published in 2005 reported assimilated data including 61 studies with 2,603 pregnancies with an indication for prophylactic LMWH and 15 studies with therapeutic LMWH in 174 patients. In the thromboprophylaxis group, significant maternal bleeding occurred in 2% of the women (95% CI: 1.5–2.6). In 2014, a systematic review, investigating intermediate dosing of LMWH in the long-term treatment of pregnancy-associated thromboembolism, reported a pooled proportion of 0.012 VTE recurrences during long-term treatment (95% CI: 0.0007–0.035) and found no major antepartum bleeding. Only 1 out of 152 patients developed a recurrent VTE. In the postpartum period, major bleeding was reported as abnormal postpartum bleeding in 0.02 (95% CI: 0.002–0.05). Overall, the rate of fatal bleeding complications in pregnant women receiving LMWH seems very low, but solid evidence in this field is missing as most data are derived from retrospective studies on LMWH that did not systematically assess antepartum or postpartum bleeding. One only of 152 patients developed a recurrent VTE. In the postpartum period, major bleeding was reported as abnormal postpartum bleeding in 0.02 (95% CI: 0.002–0.05). Overall, the rate of fatal bleeding complications in pregnant women receiving LMWH seems very low, but solid evidence in this field is missing as most data are derived from retrospective studies on LMWH that did not systematically assess antepartum or postpartum bleeding. In addition, the optimal dose of LMWH prophylaxis especially in the antepartum period is still a matter of debate and ongoing trials such as the Highlow RCT (www.ClinicalTrials.gov identifier NCT01828697) are currently collecting data to solve this issue.

**Risk of Recurrent VTE despite Thromboprophylaxis**

There is a substantial paucity of randomized controlled trials for the appropriate dosage for VTE prevention of LMWH in pregnant women. The vast majority of data derive from retrospective cohort studies and only two very small placebo controlled trials. – Fig. 3 summarizes selected studies emphasizing the risk of “break-through thrombosis” (a thrombosis despite adequate thromboprophylaxis) with different strategies in heparin prophylaxis of VTE during pregnancy and puerperium.

An updated Cochrane review on VTE prophylaxis during pregnancy and puerperium recently reported on the efficacy of antenatal ± postnatal heparin prophylaxis in 476 women from four clinical trials. A wide indication for LMWH included primary prevention, prevention of pregnancy complications; thus, some women with thrombophilia, known family history of VTE, or caesarean section were at increased risk. In this meta-analysis, the use of LMWH versus no treatment or placebo was associated with a relative VTE risk (RR) of 0.39 (95% CI: 0.08–1.98). The review concluded that the evidence of heparin prophylaxis is still very uncertain regarding risk–benefit analysis. Trials with moderate to high bias were observed.

Results from the Highlow study (NCT01828697), which recruited more than 1,100 women between 2013 and 2020, are expected to provide high-quality data on this topic with its international randomized controlled multicenter trial design in the prevention of pregnancy-associated recurrent VTE comparing low-dose LMWH with intermediate-dose LMWH.
Guideline Recommendations for Risk-Adapted VTE Prophylaxis in Pregnancy and Puerperium

Current international guideline recommendations are mainly based on observational and retrospective data and are inconclusive regarding indication, intensity, and duration of thromboprophylaxis in certain risk constellations during pregnancy and puerperium. Despite its long-time and widespread use, optimal dosage of LMWH has not been appropriately evaluated in extended randomized studies. Furthermore, the widespread use of LMWH to prevent non-VTE pregnancy complications may indirectly reduce the VTE risk in these observational studies, impairing adequate risk estimations. So far, only two small randomized controlled pilot trials \((n = 16 \text{ and } n = 40)\) have been conducted in prevention of recurrent VTE.\(^{61,62}\)

Personal History of VTE

A personal history of VTE is considered the strongest individual risk factor for VTE recurrence in pregnancy, and all women with prior VTE should be offered counseling and VTE risk assessment prior to pregnancy. In general, the threshold for recommending postpartum prophylaxis is lower than for antepartum prophylaxis since the risk for VTE per day is higher and the duration for complication (i.e., bleeding and burden of daily injections) is shorter.

In accordance with numerous international guidelines,\(^{11,14,32,33,37,49,66}\) all women with a personal history of VTE, irrespective of the circumstances of prior VTE occurrence, should be offered postpartum thromboprophylaxis for at least 6 weeks.

For women with a personal history of an unprovoked or hormone-related VTE (i.e., prior pregnancy-related VTE or VTE occurrence in the context of hormonal contraception) and without indication for long-term anticoagulation outside pregnancy, both antepartum and postpartum thromboprophylaxis is recommended. If antepartum is indicated, LMWH should be started as soon as possible after pregnancy has been confirmed. However, one should note that some guidelines deviate from this overall consensus. For instance, the RCOG guideline (2015)\(^{37}\) suggests to initiate thromboprophylaxis only in the third trimester after the 28th gestational week in all women with prior provoked VTE and without any other VTE risk factors.

Although the far minority of young women with VTE, those who experienced a single prior VTE provoked by a nonhormonal major transient risk factor (i.e., trauma, surgery, immobility) in the absence of hormonal treatment or pregnancy, postpartum-only prophylaxis for 6 weeks is suggested.\(^{32}\)

Women with Known Thrombophilia

High-quality data for the reasonable use of antithrombotic prophylaxis in women without a personal history of VTE with known thrombophilia are still limited. Thus, there is no general consensus, and international guideline recommendations differ widely on the topic of thromboprophylaxis in asymptomatic thrombophilia. A reasonable approach could be to grade the types of thrombophilia in different risk categories and consider the family history of VTE as well as additional VTE risk factors in context.

Table 3 provides an overview over the recent international guideline recommendations for ante- and postpartum thromboprophylaxis for women with thrombophilia in the absence of a personal history of VTE and different risk scenarios (adapted from the Working Group in Women’s Health of the Society of Thrombosis and Haemostasis [GTH] guideline 2020).\(^{11,41}\) Most guidelines suggest antepartum thromboprophylaxis for pregnant women without a personal history of VTE only in those with both high-risk thrombophilia and a positive family history of VTE. In women with high-risk thrombophilia without positive family history of VTE, antepartum prophylaxis is recommended by the Society of Obstetricians and Gynaecologists of Canada (SOGC), RCOG, American College of Obstetricians and Gynecologists (ACOG), and GTH guidelines, whereas the ASH guidelines favor no prophylaxis in these cases. In women with a low-risk thrombophilia with or without a positive family history of VTE, antepartum thromboprophylaxis is not recommended but has to be considered in the presence of additional risk factors as suggested by SOGC, RCOG, ACOG, and GTH. The threshold for recommendation on postpartum prophylaxis is lower and should be offered to all women with high-risk thrombophilia regardless of a positive family history.

Antithrombotic Prophylaxis for Women with Pregnancy Complications

In women with pregnancy complications (e.g., recurrent pregnancy loss, fetal loss, preeclampsia, HELLP syndrome, and intrauterine growth restriction), the question frequently arises whether aspirin or LMWH may be of benefit to reduce recurrence of such complications. Particularly in women with APS, aspirin and heparin are widely used. This practice and guideline recommendation is based on only a few intervention studies, and uncertainty regarding benefits and risk remains.\(^{67}\) In a recent systematic review,\(^{68}\) the effect of heparin (LMWH or UFH), aspirin, or both on live birth rates in women with persistent antiphospholipid antibodies and recurrent pregnancy loss was assessed and included 11 randomized controlled trials. Aspirin alone did not increase live birth rate compared with placebo in one trial of 40 women (RR: 0.94; 95% CI: 0.71–1.25). One trial of 141 women reported a higher live birth rate with LMWH only than with aspirin alone (RR: 1.20; 95% CI: 1.00–1.43). Five trials (1,295 women) compared heparin plus aspirin with aspirin only. The pooled RR for live birth was 1.27 (95% CI: 1.09–1.49) in favor of heparin plus aspirin.

For women with inherited thrombophilia and pregnancy complications, it is unknown whether heparin benefits outcomes such as recurrent pregnancy loss and preeclampsia.\(^{69,70}\) Again, in these women, aspirin and LMWH are still widely prescribed. The ALIFE2 study (www.trialregister.nl, ntr3361) including women with inherited thrombophilia...
Table 3  International guideline recommendations for ante- and postpartum thromboprophylaxis for women with thrombophilia but without personal history of VTE

<table>
<thead>
<tr>
<th>Type of hereditary thrombophilia</th>
<th>Family history of VTE (1st degree)</th>
<th>ACCP 2012</th>
<th></th>
<th></th>
<th>RCOG 2015</th>
<th></th>
<th></th>
<th>ASH 2018</th>
<th></th>
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<tr>
<td></td>
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<td>Postpartum</td>
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<td>Protein S deficiency(^a)</td>
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<td>Antithrombin deficiency(^a)</td>
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<td>Factor V Leiden homzygous</td>
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<td>Prothrombin mutation homozygous</td>
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<td>Combined factor V and prothrombin mutation</td>
<td>No recommendation</td>
<td>No recommendation</td>
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Abbreviations: ACCP, American College of Chest Physicians; ASH, American Society of Hematology; GTH, the Working Group in Women’s Health of the Society of Thrombosis and Haemostasis; RCOG, Royal College of Obstetricians and Gynaecologists; VTE, venous thromboembolism.

Yes and No: Consider thromboprophylaxis based on the presence and extent of other risk factor.

Source: Adapted from Hart et al, Bistervels et al, ACCP (2012), RCOG (2015), and ASH (2018).\(^{11,32,37,41,49}\)

\(^a\)Protein S, protein C, and antithrombin deficiency is considered high risk by RCOG, and by GTH in case of severe deficiency (PC activity < 50%, PS activity < 40%, AT activity < 60%).

\(^b\)No formal recommendation as no family studies available in homozygous prothrombin mutation. Guideline favors antepartum prophylaxis given the VTE risk estimates.
and at least two pregnancy losses has completed recruitment and results are expected in 2022.

Finally, there is ample evidence that aspirin and LMWH do not improve the outcome of pregnancy in women with unexplained pregnancy loss or late placenta-mediated complications.\textsuperscript{71,72}

### What Is Known About the Subject

- The risk of developing venous thromboembolism (VTE) is increased and evidence of thromboprophylaxis is sparse during pregnancy and puerperium and with different types of thrombophilia.
- Despite thromboprophylaxis, the risk reduction of VTE in pregnant and lactating women, as well as during puerperium, is comparable with other high-risk prophylaxis indications like extended LMWH prophylaxis following major orthopaedic surgery.
- International guidelines provide recommendations or suggestions for thromboprophylaxis in pregnant or breastfeeding women and in puerperium.
- For thromboprophylaxis during pregnancy complications, the use of LMWH and ASS is frequently discussed.

### What This Paper Adds

- An overview over risk factors and their influence during ante- and postnatal period with a current literature review regarding acquired and hereditary thrombophilia and selected VTE prevention strategies is provided.
- Recurrent thrombosis in pregnancy and puerperium is not zero and the vast majority of data come from two small placebo-controlled trials and retrospective cohort studies.
- Current guideline recommendations for antepartum women are inconclusive regarding thromboprophylaxis in special constellations in women with thrombophilia. They also differ in puerperium, but to a lesser extent.
- In women with APS, a recent overview of indication for heparin and aspirin is discussed, but in women suffering from unexplained pregnancy loss or late placenta-mediated complications, there is clear evidence that heparin and aspirin do not improve outcomes.

### Conflict of Interest

The authors declare that they have no conflict of interest.

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Role of Thrombophilia in Pregnancy

Middeldorp et al.


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