**The utility of thrombophilia testing**

**Abstract:** In the past decades, the recognition of several inherited thrombophilic traits has greatly improved our knowledge of the pathogenesis of venous thromboembolism, explaining about half of all idiopathic cases. As a consequence, thrombophilia testing has enormously increased in the past years for various clinical conditions. In this paper, the current indications of the most commonly tested thrombophilic abnormalities (i.e., Factor V Leiden, prothrombin G20210A mutation, protein C, S and antithrombin deficiencies) are analysed. When used appropriately thrombophilia testing has a positive impact on the health care of the people tested and their relatives.

**Keywords:** Factor V Leiden; inherited thrombophilia; prothrombin mutation; testing.

In the past five decades our knowledge on the aetiology of venous thromboembolism (VTE) has dramatically improved [1–3]. Indeed, the recognition of a number of inherited coagulation abnormalities, first the deficiencies of natural anticoagulant proteins C and S and then the gain-of-function mutations Factor V Leiden and prothrombin G20210A [4–8], has allowed the identification of a thrombophilic defect in at least 50% of cases with idiopathic VTE. Accordingly, the number of patients tested for thrombophilia has exponentially increased in the last years, despite the usefulness and cost-effectiveness of testing still remains a matter of debate [9, 10].

Table 1 shows epidemiological data and association with risk of VTE of the most commonly tested thrombophilic defects. Overall, literature data shows that deficiencies of natural anticoagulant proteins are relatively rare (<0.5% in the general population), but are associated with a more severe thrombophilic tendency, with an increased risk of 5–10-fold and annual incidence of VTE >1% [11]. Conversely, Factor V Leiden and prothrombin G20210A polymorphisms are more common abnormalities, with a prevalence of about 5% in the general population and up to 50% of patients with VTE, especially in studies on familial thrombophilia [12]. However, these mutations are associated with a lower increase of risk (2–5-fold) and incidence of VTE (<0.5% per year). Notably, patients carrying homozygous Factor V Leiden or combined defects show a more severe phenotype, with a 20–50-fold increased risk and an earlier onset of first VTE or recurrence. Interestingly, the different thrombotic risks associated with thrombophilic traits interplay in different manners with concomitant acquired conditions (see below) for development of VTE. Thus, a higher prevalence of unprovoked VTE (55%–60%) is observed in patients with natural anticoagulant deficiencies, who frequently show the first thrombotic event before 45 years of age. Globally, approximately 50% of subjects with antithrombin deficiency will have developed a VTE episode by 50 years of age. Conversely, patients with Factor V Leiden often develop the first VTE episode after 45 years of age, most frequently in association with acquired (triggering) risk factors such trauma, surgery, pregnancy and oral contraceptives [13]. Among these well-established genetic factors, there is growing evidence that non-O blood group, which is associated with approximately 25% higher plasma von Willebrand factor and factor VIII levels (which are well-known thrombotic risk factors) than those in O blood type individuals, is associated with an approximately two-fold increased risk of VTE [14].

Clinical and epidemiological studies on prevalence of these thrombophilic traits, as well as on their association with development of VTE (Table 1), have led to defining the multifactorial nature of VTE, in which the thrombotic event is the result of multiple gene-gene and/or gene-environment interactions. In keeping with this model, inherited thrombophilia interacts with several other well-established acquired predisposing factors for VTE such as age, malignancy, inflammatory states, antiphospholipid antibodies, surgery, trauma, immobility, pregnancy-puerperium, use of oral contraceptives or hormone replacement therapy, elevated body mass index, severe infections and venous abnormalities. Overall, this model provides a dynamic concept of the thromboembolic risk, encompassing a genetic predisposition (one or more
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co-inherited thrombophilic abnormalities) and a variable contribution of environmental factors (possibly modifiable or preventable) during different ages, which may lead to overcome a threshold and trigger the VTE episode [3]. Therefore, inherited thrombophilia should be evaluated in the framework of coexisting risk factors for first or recurrent VTE when assessing the need and modalities of primary or secondary prophylaxis.

Thus, taking into account these considerations, it appears evident that universal population screening for thrombophilia is unjustified and that screening should be performed only in well-selected cases [15]. The current indications for thrombophilia screening include (Table 2): idiopathic thrombosis and/or age <50 years and thrombosis, venous thrombosis in unusual sites (such as hepatic, mesenteric and cerebral veins), recurrent VTE, first VTE and a strong family history of VTE, VTE during pregnancy, postpartum or in women taking oral contraceptives or under hormone replacement therapy, women with unexplained pregnancy loss and asymptomatic adult family members of relatives with documented inherited thrombophilia. Importantly, testing for thrombophilia in patients during the thrombotic episode is not indicated as many of those laboratory tests are functional and can hence result abnormal as a consequence of the inflammatory state rather than of the inherited defect.

In general, screening for thrombophilia is only reasonable when it may influence the future management of affected patients. However, whether the presence of thrombophilia is able to predict VTE recurrence is still a matter of debate [16]. The estimated risk of recurrence for VTE is approximately 5% per year, although idiopathic cases tend to recur more frequently (approx. 20% in the first 2 years) than unprovoked cases [1]. Several follow-up studies have compared the prevalence of thrombophilia in patients with recurrent VTE with those without recurrence with conflicting results [16]. For instance, two large prospective trials found that carriers of a thrombophilic defect (Factor V Leiden, prothrombin G20210A, protein C, S and antithrombin deficiencies) did not show a highly increased risk of developing a recurrent venous thrombotic event [17, 18]. Two meta-analyses analysed the risks of recurrence in patients with the common thrombophilias, i.e., FVL and prothrombin G20210A mutation. The risk of recurrence was found consistently to be 1.3–1.4-fold higher in patients with FVL and 1.4–1.7-fold higher in patients with the prothrombin mutation [19, 20]. Data on natural anticoagulant deficiencies are less extensive, because only a few studies with a limited number of patients have assessed the risk of VTE recurrence associated with these thrombophilic abnormalities, suggesting limited effects on the risk of recurrent VTE [16]. However, a recent study reported a higher risk of VTE recurrence during follow-up in patients with deficiencies of natural anticoagulants compared with the risk of recurrence in the general VTE population [21]. Inherited thrombophilia has also been implicated in pregnancy complications, such as recurrent miscarriage, foetal death, preeclampsia and intra-uterine

<table>
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<th>Thrombophilia</th>
<th>Prevalence, %</th>
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<td>12–20</td>
<td>4.9–9.7</td>
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<tr>
<td>Factor V Leiden homozygous</td>
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<td>1.5</td>
<td>40–80</td>
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<td>Prothrombin G20210A</td>
<td>1–3</td>
<td>3–8</td>
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</tr>
<tr>
<td>Factor V Leiden+prothrombin G20210A</td>
<td>0.01</td>
<td>–</td>
<td>20–58.6</td>
</tr>
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VTE, venous thromboembolism.
growth retardation, although a causal association is still controversial [22]. Thus, thrombophilia testing appears more useful for the identification of asymptomatic family members of thrombophilic patients. Indeed, identifying a thrombophilic trait in the latter cases is very helpful since these individuals, who have a 2–10-fold increased risk for VTE as compared with non-carriers [1], may benefit from targeted thromboprophylaxis in high-risk situations (e.g., pregnancy, puerperium, surgery, immobilisation and trauma), and the avoidance of acquired risk factors, most notably oral contraceptives.

In conclusion, thrombophilia tests represent an important tool for assessing the subjects’ thrombotic risk and their recognition allows physicians to individualise treatment strategies and preventative measures in selected groups of patients.

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References