TH Open

Thrombophilia Testing: from Genetic Predisposition to Discrimination

Andreas Verstraete, Kathleen Freson, Peter Verhamme, Thomas Vanassche.

Affiliations below.

DOI: 10.1055/a-2284-4285

Please cite this article as: Verstraete A, Freson K, Verhamme P et al. Thrombophilia Testing: from Genetic Predisposition to Discrimination. TH Open 2024. doi: 10.1055/a-2284-4285

Conflict of Interest: Andreas Verstraete has no conflicts of interest. Kathleen Freson is supported by research grants from KULeuven BOF (C14/19/096 and C14/23/121), FWO (G072921N) and Swedish Orphan Biovitrum AB (Sobi). Peter Verhamme has received research funding from Bayer, BMS, Pfizer, and Leo Pharma, and honoraria from Bayer, Pfizer, BMS, Daiichi-Sankyo, Sanofi-Aventis, Leo Pharma, and Anthos Therapeutics, Astra-Zeneca. Thomas Vanassche has participated in advisory boards and/or acted as a speaker on behalf of Bayer, BMS/Pfizer, Boehringer Ingelheim, Daiichi Sankyo, Leo Pharma, Sanofi Aventis. TVA is supported by a grant from research foundation Flanders (FWO) grant n°1843423N.

Abstract:
N/A for letters to the editor

Corresponding Author:
Dr. Andreas Verstraete, University Hospitals Leuven, Department of Cardiovascular Diseases, Leuven, Belgium, andreas.verstraete@kuleuven.be

Affiliations:
Andreas Verstraete, University Hospitals Leuven, Department of Cardiovascular Diseases, Leuven, Belgium
Andreas Verstraete, Katholieke Universiteit Leuven, Department of Cardiovascular Sciences, Center for Molecular and Vascular Biology, Leuven, Belgium
Kathleen Freson, Katholieke Universiteit Leuven, Department of Cardiovascular Sciences, Center for Molecular and Vascular Biology, Leuven, Belgium
[...]
Thomas Vanassche, Katholieke Universiteit Leuven, Department of Cardiovascular Sciences, Center for Molecular and Vascular Biology, Leuven, Belgium
Thrombophilia Testing: from Genetic Predisposition to Discrimination

Andreas Verstraete¹², Kathleen Freson², Peter Verhamme¹², Thomas Vanassche¹²

¹Department of Cardiovascular Diseases, University Hospitals Leuven, Leuven, Belgium.
²Department of Cardiovascular Sciences, Center for Molecular and Vascular Biology, KU Leuven, Leuven, Belgium

Corresponding author: Andreas Verstraete
- Department of Cardiovascular Diseases, University Hospitals Leuven, Leuven, Belgium
- Herestraat 49, bus 911, 3000 Leuven, Belgium
- E-mail: andreas.verstraete@kuleuven.be

Venous thromboembolism (VTE) is a multifactorial disease arising from a complex interplay between acquired clinical risk factors and inherited genetic predispositions. VTE is a common condition and occurs in 1-2 per 1000 people every year in Western countries.¹² Laboratory tests for inherited thrombophilia are frequently requested with the goal to uncover the susceptibility to VTE in patients devoid of major clinical risk factors. Conventional thrombophilia testing typically involves the determination of deficiencies in antithrombin, protein C and protein S, and genetic testing for the factor V Leiden (FVL) and prothrombin G20210A variants.³ However, despite their widespread use, these tests are critically flawed with limited sensitivity and specificity for VTE, as well as with methodological issues. Moreover, conventional thrombophilia tests fail to differentiate between patients at high and low risk of VTE recurrence.⁴⁻⁶ Additionally, thrombophilia testing introduces risks, with potential long-term personal consequences if the information is misinterpreted or
inappropriately applied. As a consequence, current guidelines recommend against the routine use of thrombophilia tests.\textsuperscript{7–10} Nonetheless, there is substantial non-adherence to the guidelines in clinical practice. In a recent, large, single-centre cross-sectional study, merely one-third of thrombophilia tests were conducted according to the guidelines.\textsuperscript{11} Furthermore, the study underscored the limited therapeutic value, with only 8.3% of thrombophilia tests influencing anticoagulant treatment decisions.\textsuperscript{11}

To underscore the importance of judicious use of thrombophilia tests and to highlight their potential psychological and social consequences, we here present three unrelated cases of genetic discrimination after testing for inherited thrombophilia. The cases were selected from the outpatient clinic of the Thrombosis and Haemostasis Department at the University Hospitals Leuven, Belgium. All three patients presented between 2020 and 2023 after medical disqualification by the police department based on the results of previous thrombophilia tests. To the best of our knowledge, no additional cases of discrimination resulting from thrombophilia testing were documented at our institution. The retrospective study of our cases was approved by the Ethics Committee Research UZ/KU Leuven. Informed consent for publication was obtained from all three patients.

Case 1

A 22-year-old woman in good overall health externally underwent selective FVL testing after her grandfather was tested heterozygous for FVL following a thrombotic event. Her test revealed that she was also a heterozygous carrier of FVL. She switched from the oestrogen-progestogen contraceptive pill to a progestogen-only pill. She has never experienced any thrombotic event.

Case 2
A 20-year-old man, with an unremarkable medical history besides a tonsillectomy and a traumatic radius fracture, was selectively tested for FVL by his haematologist because of his mother’s history of a contraceptive pill related deep vein thrombosis and positive FVL testing. The results showed heterozygosity for FVL. No specific interventions were undertaken.

Case 3

A 36-year-old man, with no medical history, underwent thrombophilia testing via his general practitioner after his mother was found to have FVL heterozygosity following an unprovoked deep vein thrombosis. The test showed normal plasma levels for antithrombin, protein C and protein S, but clear activated protein C (APC) resistance. Further genetic testing verified his heterozygous FVL carriership. Genetic testing for the prothrombin G20210A variant was not performed. He was advised to start thromboprophylaxis in high-risk situations and to maintain increased vigilance towards VTE symptoms.

Despite their overall good medical condition, all three individuals were denied by the medical department of the police academy based solely on their asymptomatic carriership of FVL. The decision was grounded in the perceived higher risk of VTE associated with the combination of FVL and their potential employment as police officers.\textsuperscript{12}

The decision for medical disqualification is fundamentally unfair. The interpretation of the clinical consequences of a positive thrombophilia test by the police department was incorrect, thereby illustrating the risks and complexities of thrombophilia tests. Moreover, these cases highlight the importance of judicious use of thrombophilia tests, considering the
absence of a proper indication for testing according to the most recent 2023 guidelines from the American Society of Hematology (ASH).10

Prevalence and VTE risk of factor V Leiden

FVL results from a single missense variant in the F5 gene (p.Arg534Gln, historically reported as p.Arg506Gln). Hence, a prothrombotic FV protein arises, characterized by an increased resistance to inactivation by APC and a loss of FV's anticoagulant cofactor activity in the degradation of FVIIIa by APC.13 FVL is the most common genetic risk factor associated with VTE, with a prevalence of ~5% among Caucasians and ~20% in unselected individuals with VTE.14–16 Heterozygosity for FVL is associated with a fourfold increase in the risk of VTE, and this risk further escalates to a factor eleven in those with homozygosity for FVL.17 Nevertheless, the absolute risk of VTE remains low, with an annual incidence ranging from 0.45% to 0.67% per year in asymptomatic heterozygous carriers, compared to the overall population incidence of ~0.1% to 0.2% per year.18–20 In FVL carriers under 30 years of age, this incidence is even lower at 0.25% per year.18,19 Ultimately, only ~11% of all FVL carriers will develop VTE during their lifetime, with over half of these events being triggered by clinical risk factors such as recent surgery, trauma or pregnancy.18,19,21 Thus, FVL should only be considered as a genetic 'risk factor' as it is not at all fully penetrant for VTE. The thrombotic risk associated with FVL carriership does not justify routine thromboprophylaxis in asymptomatic carriers, given the increased bleeding risk associated with anticoagulant treatment. When VTE does occur, the treatment is generally uncomplicated, and neither the choice nor the duration of treatment is typically influenced by the presence of FVL. Clinical decision-making regarding VTE therefore relies on clinical factors rather than the presence of
hereditary thrombophilia. Consequently, this genetic risk factor on itself is not a reason to declare someone unfit for a profession.

Guidelines on thrombophilia testing

Thrombophilia tests may provide insights into the aetiology of (unprovoked) VTE, yet their therapeutic implications are currently limited. Current guidelines therefore recommend against their routine use in clinical practice (table 1).\textsuperscript{7-10} Instead, thrombophilia tests should only be performed when results will influence management. However, due to a lack of randomized controlled trials, the level of evidence supporting these guidelines is weak. Moreover, guidelines are inconsistent and ambiguous, resulting in poor adherence and misuse in clinical practice.\textsuperscript{11} According to the guidelines, thrombophilia tests should not be performed in asymptomatic men with known familial FVL, as in case 1 and 3.\textsuperscript{7-10} Nonetheless, guidelines disagree on testing asymptomatic women with familial FVL, as in case 2 (table 1).

The most recent 2023 ASH guidelines recommend thrombophilia testing for patients with symptomatic VTE provoked by transient non-surgical risk factors, pregnancy, post-partum period, or combined oral contraceptives (COC), to determine the need for lifelong anticoagulation.\textsuperscript{10} Indefinite anticoagulation is advised for patients with confirmed thrombophilia. Additionally, thrombophilia testing is advised for asymptomatic individuals with a family history of VTE and known antithrombin, protein C, and protein S deficiency, with the recommendation for thromboprophylaxis in risk situations and avoidance of COC in thrombophilic patients. Nevertheless, thrombophilia testing is not supported for patients with VTE provoked by major risk factors, nor for asymptomatic individuals with a family
history of VTE whose familial thrombophilia status is unknown or who have a known heterozygous FVL or prothrombin G20210A variant in the family.

Risk of patient harm by thrombophilia tests

Considering not only the clinical implications but also the potential psychological and social ramifications arising from misuse or misinterpretation of thrombophilia tests is paramount in the context of thrombophilia testing (table 2). According to the 2023 ASH guidelines, all three case patients had no firm indication for thrombophilia testing and would have successfully passed medical examinations if they had not undergone such testing. Nonetheless, discrimination on any grounds, including genetics, is explicitly prohibited, as stated in Article 14 of the European Convention on Human Rights. However, genetic discrimination persists anno 2023 and continues to impact individuals’ lives. These instances are not isolated, as evidenced in a survey by Bank et al. among healthy FVL carriers, revealing reports of stigmatization in healthcare and discrimination by insurance companies.

The emergence of multigenetic thrombophilia tests to screen for (anti-)coagulation defects holds promise for enhancing diagnostic precision and counselling. However, uncertainties persist concerning the clinical usefulness and cost-effectiveness. Furthermore, pervasive genetic testing reveals numerous variants of unknown significance, complicating its use and thereby increasing the risk of misinterpretation or misapplication with potential adverse patient consequences. Future studies are imperative to ascertain the precise place of both conventional and multi-genetic thrombophilia testing within clinical practice. Until then, prudence in interpretation and rational use of thrombophilia tests are warranted to prevent potential unnecessary harm to patients.
**Acknowledgements**

AV wrote the manuscript, designed the tables and made adjustments according to the critical review of KF, PV and TV.

**Conflicts of Interest**

KF is supported by research grants from KULeuven BOF (C14/19/096 and C14/23/121), FWO (G072921N) and Swedish Orphan Biovitrum AB (Sobi). PV has received research funding from Bayer, BMS, Pfizer, and Leo Pharma, and honoraria from Bayer, Pfizer, BMS, Daiichi-Sankyo, Sanofi-Aventis, Leo Pharma, and Anthos Therapeutics, Astra-Zeneca. TVA has participated in advisory boards and/or acted as a speaker on behalf of Bayer, BMS/Pfizer, Boehringer Ingelheim, Daiichi Sankyo, Leo Pharma, Sanofi Aventis. TVA is supported by a grant from research foundation Flanders (FWO) grant n°1843423N.

**References**


17. Simone B, De Stefano V, Leoncini E, et al. Risk of venous thromboembolism associated with single and combined effects of Factor V Leiden, Prothrombin 20210A and


Table 1. Overview of guidelines for thrombophilia testing in clinical practice.

<table>
<thead>
<tr>
<th>Known familial thrombophilia</th>
<th>2009 GFHT</th>
<th>2016 ACF</th>
<th>2022 BSH</th>
<th>2023 ASH</th>
</tr>
</thead>
<tbody>
<tr>
<td>AT, PC, or PS deficiency</td>
<td>Recommended in first-degree relatives &lt; 60 y&lt;sup&gt;a&lt;/sup&gt;</td>
<td>Only considered in first-degree related women contemplating COC/pregnancy</td>
<td>Recommended in first-degree relatives</td>
<td>Recommended in first- and second-degree relatives with minor VTE risk factors, incl. postpartum and COC use&lt;sup&gt;c,d&lt;/sup&gt;</td>
</tr>
<tr>
<td>Heterozygous FVL or FII G20210A variant</td>
<td>Only recommended in women of childbearing age</td>
<td>Only considered in first-degree related women contemplating COC/pregnancy</td>
<td>Not recommended&lt;sup&gt;b&lt;/sup&gt;</td>
<td>Not recommended&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Unknown familial thrombophilia</td>
<td>Not recommended</td>
<td>Not recommended</td>
<td>Not recommended</td>
<td>Not recommended&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Secondary prevention following personal VTE

<table>
<thead>
<tr>
<th>Provoked VTE</th>
<th>Recommended in women of childbearing age</th>
<th>Not recommended</th>
<th>Not recommended</th>
<th>Only recommended when transient non-surgical risk factors, incl. postpartum and COC use&lt;sup&gt;e&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unprovoked VTE</td>
<td>Recommended in anyone &lt; 60 y</td>
<td>Only recommended if low bleeding risk and plan to stop anticoagulation</td>
<td>Only, recommended when strong personal and/or family history of thrombosis</td>
<td>Not recommended</td>
</tr>
</tbody>
</table>

<sup>a</sup>Also in case of homozygous polymorphisms for FVL and FII G20210A as well as double heterozygotes.

<sup>b</sup>Prior to COC use in women with a first-degree relative with FVL and history of thrombosis, thrombophilia testing can be discussed case by case.

<sup>c</sup>Minor provoking risk factors: immobility, minor injury, illness, infection

<sup>d</sup>In ambulatory patients with cancer at low or intermediate VTE risk, who have a first-degree relative with VTE, thrombophilia testing is recommended, regardless of known familial thrombophilia.

<sup>e</sup>Non-surgical risk factors: immobilisation > 3 days, use of COC, pregnancy, post-partum

Abbreviations: ACF, Anticoagulation Forum; AT, antithrombin; BSH, British Society of Haematology; COC, combined oral contraceptives; FVL, FV Leiden variant; GFTH, French Group of Haemostasis and Thrombosis; PC, protein C; PS, protein S; VTE, venous thromboembolism.
<table>
<thead>
<tr>
<th><strong>Pros</strong></th>
<th><strong>Cons</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>May provide insights into VTE susceptibility and improve knowledge and counselling</td>
<td>Limited sensitivity and specificity for VTE</td>
</tr>
<tr>
<td>May prevent first VTE in asymptomatic confirmed thrombophilia cases by e.g.</td>
<td>- Risk of false reassurance with negative test</td>
</tr>
<tr>
<td>- No oestrogen-progestogen contraceptive pill</td>
<td>- Risk of overtreatment with positive test</td>
</tr>
<tr>
<td>- Extending post-partum thromboprophylaxis</td>
<td></td>
</tr>
<tr>
<td>Abbreviations: VTE, venous thromboembolism</td>
<td>Limited therapeutic implications as clinical decision-making mainly relies on clinical risk factors</td>
</tr>
<tr>
<td></td>
<td>Misinterpretation and misuse:</td>
</tr>
<tr>
<td></td>
<td>- Psychological consequences: worry</td>
</tr>
<tr>
<td></td>
<td>- Social consequences (discrimination): profession, insurance</td>
</tr>
<tr>
<td></td>
<td>High costs</td>
</tr>
</tbody>
</table>