Von Willebrand Disease Genetic Subtyping – Type 2 and Platelet Type

Indications for Ordering

- Confirm a phenotypic diagnosis of von Willebrand disease (VWD) types 2A, 2B, 2M, or 2N, or platelet type
  - Aid in therapeutic recommendations
  - Aid in distinguishing type 2N from mild hemophilia A
  - Aid in distinguishing type 2B from platelet type von Willebrand disease (PT-VWD)
- Evaluate family members of individuals with known variants

Test Description

- Type 2 – polymerase chain reaction (PCR) followed by bidirectional sequencing of selected VWF exons
  - Type 2A
    - Sequences exon 28
    - Exons 11, 12, 14, 15, 16, 24, 25, 51, 52 added when no variant identified
  - Type 2B
    - Sequences exon 28
  - Type 2M
    - Sequences exon 28
    - Exons 30 and 31 added when no variants are identified
  - Type 2N
    - Sequences exons 4, 9, 17, 18, 20, 21, 24, 25, 27
  - PT-VWD – PCR of the GPIBA gene followed by targeted variant analysis

Tests to Consider

Primary tests

- von Willebrand Disease, Type 2A (VWF) Sequencing Exon 28 with Reflex to 9 Exons 2005480
  - Molecular test to confirm a phenotypic diagnosis of VWD type 2A
- von Willebrand Disease, Type 2B (VWF) Sequencing 2005486
  - Molecular test to distinguish VWD type 2B from PT-VWD
- von Willebrand Disease, Type 2M (VWF) Sequencing 2005490
  - Molecular test to confirm a phenotypic diagnosis of VWD type 2M
- von Willebrand Disease, Type 2N (VWF) Sequencing 2005494
  - Molecular test to distinguish VWD type 2N from hemophilia A

Related tests

- Familial Mutation, Targeted Sequencing 2001961
  - Useful when a pathogenic familial variant identifiable by sequencing is known
  - Initial work up of suspected vWD
- von Willebrand Panel 0030125
  - Recommended panel for the initial workup of suspected VWD
  - Panel contains the 3 recommended tests for the diagnosis of VWD
    - Factor VIII activity
    - VWF antigen
    - VWF activity (ristocetin cofactor)
- Factor VIII, Activity 0030095
  - Alternate test for the workup of VWD
  - Lacks VWF activity (ristocetin cofactor) and antigen tests
- von Willebrand Factor Antigen 0030285
  - Do not use as a standalone test to diagnose VWD
- von Willebrand Factor Activity (Ristocetin Cofactor) 0030250
  - Do not use as a standalone test to diagnose VWD
- von Willebrand Modified Panel 0030284
  - Alternate test for the workup of VWD
  - Lacks factor VIII activity test
  - Subclassify established VWD to assist with therapeutic decisions
- von Willebrand Panel with Reflex to von Willebrand Multimeric Analysis 2003387
  - Recommended panel to subclassify VWD when high suspicion for VWD exists
  - Contains VWF multimers, factor VIII activity, VWF antigen, and VWF activity (ristocetin cofactor)
  - Multimeric testing is performed when ristocetin cofactor, VWF antigen, or factor VIII activity is low or if the ratio of ristocetin cofactor to VWF antigen is <0.7
- von Willebrand Factor Multimers 0092281
  - Order to assist with diagnosis and subclassification of inherited or acquired von Willebrand disease in conjunction with factor VIII activity, VWF antigen, and VWF activity
von Willebrand Multimeric Panel 0030002
• Not recommended except in suspected cases of acquired VWD or high suspicion of VWD
• Contains VW multimeric, factor VIII activity, VWF antigen, VWF activity (ristocetin cofactor)

Disease Overview

Incidence – 1/100-1,000 individuals

Symptoms
• Mucocutaneous bleeding after brushing or flossing teeth
• Unexplained bruising
• Prolonged repeated nosebleeds
• Menorrhagia
• Prolonged bleeding following childbirth, trauma, or surgery
• VWD is classified by VWF status (deficiency versus abnormal)
• See table

Genetics

Genes
• Type 2 – VWF
• Platelet – GP1BA

Inheritance
• Autosomal dominant – types 2B, 2M, most of 2A, and PT-VWD
• Autosomal recessive – 2N, and 20% of 2A

Penetration
Autosomal dominant types 2A, 2B, and 2M
• Incomplete penetrance when VWF:Ag and VWF:RCo levels are 25-50 IU/dL
• Full penetrance is expected when VWF:Ag and VWF:RCo levels are <25 IU/dL

Structure/function
VWF – large multimeric glycoprotein
• Plays a critical role in hemostasis
• VWF binds factor VIII to protect it from premature degradation
• Causes platelet recruitment via GP1BA receptor
• Facilitates clot formation

Variants
GP1BA variants
• c.746 G>T, (p.Gly249Val)
• c.746 G>A (p.Gly249Ser)
• c. 763A>G (p.Met255Val)
• c. 1306del 27 (p.436-444 del 9)

Test Interpretation

Sensitivity/specificity
• Clinical sensitivity
  o 80% for VWD types, 2B, and 2M
  o 99% for 2A and unknown for other VWD subtypes
• Analytical specificity and sensitivity – 99% for type 2

Results

Type 2A (VWF) Sequencing
• Positive – 1 pathogenic type 2A VWF gene variant was detected
  o Individual may be affected if the variant is dominant
  o If the variant is recessive, individual is at least a carrier of VWD
• Uncertain – 1 variant of uncertain significance was detected
• Negative – no pathogenic VWF gene variant detected

Type 2B (VWF) Sequencing
• Positive – 1 pathogenic variant detected
  o Individual is at risk to be affected with type 2B VWD
• Uncertain – 1 variant of uncertain significance was detected
• Negative – no pathogenic variants detected
  o Individual may still be affected with VWD if an undetected pathogenic variant is present

Type 2M (VWF) Sequencing
• Positive – 1 pathogenic variant detected
  o Individual is at risk to be affected with type 2M VWD
• Uncertain – 1 variant of uncertain significance was detected
• Negative – no pathogenic variants detected
  o Individual may still be affected with VWD if an undetected pathogenic variant is present

Type 2N (VWF) Sequencing
• Positive
  o 2 pathogenic variants detected
    ▪ Individual is predicted to be affected with VWD
  o 1 pathogenic VWF gene variant detected
    ▪ Individual is at least a carrier and may be affected if an undetected VWF variant is present
• Negative – no pathogenic variants detected
  o Individual appears to be neither a carrier of or affected with type 2N VWD
  o A negative result for type 2N sequencing would be expected in patients with hemophilia A

GP1BA Variant Detection
• Positive – 1 pathogenic variant detected
  o Individual predicted to be affected with PT-VWD
• Negative – negative for 4 variants tested in the GP1BA gene
  o Risk for PT-VWD is reduced, but not eliminated
  o Individual may have a rare GP1BA variant
Limitations
• A negative result does not eliminate the possibility of VWD as undetected pathogenic variant(s) may be present in 1 of the unsequenced exons, a noncoding region, or the promoter
• VWF sequencing may identify sequence variants with uncertain clinical significance
• VWF variants, other than those in exons tested, will not be detected
• Large VWF deletions/duplications will not be detected
• No GP1BA variants, other than the 4 targeted, are detected by analysis for PT-VWD
• Rare diagnostic errors may occur due to primer-site variants

<table>
<thead>
<tr>
<th>Clinical Characteristics of Subtypes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type</strong></td>
</tr>
<tr>
<td>Type 1 – 70-80% of cases</td>
</tr>
</tbody>
</table>
| Type 2 – 15-30% of cases | Structurally or functionally abnormal VWF | Highly variable  
• 2A – mild to moderate mucocutaneous bleeding  
  o May have thrombocytopenia  
• 2B – mild to moderate mucocutaneous bleeding  
  o Thrombocytopenia may be present  
  o Enhanced ability of VWF to bind platelet receptor GP1BA, causes removal of the platelet/VWF complex  
• 2N – symptoms are similar to hemophilia A, but with predominant mucocutaneous bleeding |  
• 2A – desmopressin therapy may worsen the thrombocytopenia; treatment for severe bleeding episodes may require clotting factor concentrates  
• 2B – desmopressin therapy may worsen the thrombocytopenia; clotting factor concentrates may be required  
• 2M – response to desmopressin is usually very poor; may require clotting factor concentrates  
• 2N – desmopressin for minor bleeding; severe bleeding requires concentrate with both VWF and factor VIII |
| Type 3 – rare | Complete absence of VWF | Severe mucocutaneous and musculoskeletal bleeding | Requires clotting factor concentrates containing both VWF and factor VIII |
| Platelet-type (PT-VWD or pseudo-VWD) | Abnormal high-affinity interaction between platelet glycoprotein Ib/V/IX complex and VWF Caused by GP1BA variants | Often indistinguishable from VWD type 2B |  