



von Willebrand Factor Antigen Test Kit

For *In Vitro* Diagnostic Use

INTENDED USE

An enzyme-linked immunosorbent assay (ELISA) for the quantitative determination of von Willebrand Factor Antigen (vWF:Ag) in citrated human plasma.

SUMMARY AND EXPLANATION OF THE TEST

Von Willebrand Factor Antigen (vWF:Ag or Factor VIII-related protein) is a plasma protein found in circulation combined by non-covalent interactions with Factor VIII (FVIII:C), a pro-coagulant protein also known as the anti-hemophilic factor. These two proteins show distinct biochemical and functional properties as well as different antigenic determinants; their plasma levels may vary independently of each other.^{1,2} Deficiency of FVIII causes classic hemophilia while deficiency of vWF causes von Willebrand disease. Most of vWF:Ag is synthesized and stored by endothelial cells while 15-20% is synthesized by megakaryocytes and stored in circulating platelets. A vWF:Ag unit has a molecular weight of about 250 kD and tends to polymerize in circulation, with multimers ranging in size from 850kD to as large as 15×10^6 D.³

vWF:Ag plays a very important role in hemostasis; it protects FVIII from proteolytic cleavage in circulation and helps platelets to aggregate or to adhere to sites of vascular damage. The *in vivo* half-life of FVIII:C without vWF:Ag is shortened from 10-12 hours to a few minutes. These two mechanisms prevent bleeding. Von Willebrand disease is characterized by an inherited deficiency of vWF. A decreased vWF activity in plasma can be the result of low concentrations (quantitative or type I defect) or a deficient function of vWF (qualitative or type II defect).^{4,5} Von Willebrand disease is the most common inherited bleeding disorder characterized by easy bruising and prolonged bleeding from mucosal surfaces. The prevalence of von Willebrand disease has been estimated to be 1-3% of the general population. Approximately 80% of von Willebrand disease patients have a type I deficiency.⁶

The laboratory diagnosis of von Willebrand disease may require both quantitative and qualitative (functional) determinations.^{7,8} Quantitative determinations are based on immunologic techniques such as radial immunodiffusion in gel and Laurell rocket immunoelectrophoresis. ELISA procedures⁹ applied to measure vWF:Ag are less labor intensive and offer several advantages including more objective, accurate and reproducible results. In addition, ELISA allows automation with commonly available laboratory instruments.

PRINCIPLE OF THE TEST

REAADS vWF:Ag assay is a sandwich ELISA. A capture antibody specific for human vWF is coated to 96-microwell polystyrene plates. Diluted patient plasma is incubated in the wells, allowing any available vWF:Ag to bind to the anti-human vWF antibody on the microwell surface. The plates are washed to remove unbound proteins or other plasma molecules. Bound vWF:Ag is quantitated using horseradish peroxidase (HRP) conjugated anti-human vWF detection antibody. Following incubation, unbound conjugate is removed by washing. A chromogenic substrate of tetramethylbenzidine (TMB) and hydrogen peroxide (H_2O_2) is added to develop a colored reaction. The intensity of the color is measured in optical density (O.D.) units with a spectrophotometer at 450nm. Patient vWF:Ag in relative percent concentration is determined against a curve made from the reference plasma provided with the kit.

REAGENTS

Store at 2-8°C. Do Not Freeze.

Each REAADS von Willebrand Factor Antigen (vWF:Ag) 96-microwell Test Kit contains the following reagents:

- 96 stabilized antibody coated microwells (12 strips of 8 breakaway wells), with frame. Wells are coated with anti-human von Willebrand Factor antibody.
- 1 bottle (60 mL) Sample Diluent (blue-green solution); contains sodium azide.
- 3 vials (0.5 mL) lyophilized Reference Plasma for preparation of reference curve, with assay sheet.
- 1 bottle (12 mL) HRP conjugated anti-human vWF Antibody Solution (red solution).
- 1 bottle (13 mL) One Component Substrate (TMB and H₂O₂).
- 1 bottle (15 mL) Stopping Solution (0.36N sulfuric acid).
- 1 bottle (30 mL) Wash Concentrate [33X phosphate buffered saline (PBS) with 0.01% Tween 20]. Note: turbidity may appear in wash concentrate which will not affect component performance and should disappear when working dilution is prepared.

WARNINGS AND PRECAUTIONS

For *In Vitro* Diagnostic Use

1. Human source material used to prepare the reference plasma included in this kit has been tested and shown to be negative for antibodies to HBsAg, HCV and HIV-I & II by FDA required tests. However, all human blood derivatives, including patient samples, should be handled as potentially infectious material.
2. Do not pipette by mouth.
3. Do not smoke, eat, or drink in areas where specimens or kit reagents are handled.
4. Wear disposable gloves while handling kit reagents and wash hands thoroughly afterwards.
5. One component substrate can cause irritation to the eyes and skin. Absorption through the skin is possible. Use gloves when handling substrate and wash thoroughly after handling. Keep reagent away from ignition sources. Avoid contact with oxidizing agents.
6. The Sample Diluent contains sodium azide as a preservative. Sodium azide has been reported to form lead and copper azides when left in contact with these metals. These metal azides are explosive. Any solutions containing azide must be thoroughly flushed with copious amounts of water to prevent the build-up of explosive metal azides in the plumbing system.

SPECIMEN COLLECTION AND PREPARATION

Plasma collected with either 3.2% or 3.8% sodium citrate as an anticoagulant should be used as the sample matrix. Blood should be collected by venipuncture, and the sample centrifuged immediately. Remove the plasma and store at 2-8°C until testing can be performed. If not tested within 8 hours of collection, the sample should be stored at -70°C and tested within 1 month.

INSTRUCTIONS FOR USE

Materials Provided:

REAADS von Willebrand Factor Antigen Test Kit; see "Reagents," page 2, for a complete listing.

Materials Required but not Supplied:

- vWF:Ag Control Plasma. Reconstitute Control Plasma selected for use following manufacturer's instructions, and store as recommended.
- Reagent grade water (1L) to prepare PBS/Tween 20 wash solution, to reconstitute Reference Plasma, and to zero or blank the plate reader during the final assay step.
- Graduated cylinders
- Precision pipettors capable of delivering between 5 and 1000 microliters, with appropriate tips
- Miscellaneous glassware appropriate for small volume handling
- Flask or bottle, 1 liter
- Wash bottles, preferably with the tip partially cut back to provide a wide stream, or an automated or semi-automated washing system
- Disposable gloves, powder-free recommended
- Plate reading spectrophotometer capable of reading absorbance at 450 nm (with a 650 nm reference if available)
- Multichannel pipettors capable of delivering to 8 wells simultaneously
- Microdilution tubes for patient sample preparation

Procedural Notes

1. Bring plasma samples and kit reagents to room temperature (18 - 26°C) and mix well before using; avoid foaming. Return all unused samples and reagents to refrigerated storage (2 - 8°C) as soon as possible.
2. All dilutions of reference plasma, control plasma selected for use, and patient samples must be made just prior to use in the assay.
3. A single water blank well should be set up on each plate with each run. No sample or kit reagents are to be added to this well. Instead, add 200 µL of reagent grade water to the well immediately prior to reading the plate in the spectrophotometer. The plate reader should be programmed to zero or blank against this water well.
4. Good washing technique is critical for optimal performance of the assay. Adequate washing is best accomplished by directing a forceful stream of wash solution from a plastic squeeze bottle with a wide tip into the bottom of the microwells. Wash solution in the water blank well will not interfere with the procedure. An automated microtiter plate washing system can also be used.
5. IMPORTANT: Failure to adequately remove residual PBS/Tween 20 can cause inconsistent color development of the substrate solution.
6. Use a multichannel pipettor capable of delivering to 8 wells simultaneously when possible. This speeds the process and allows for more uniform incubation and reaction times for all wells.
7. Carefully controlled timing of all steps is critical. All reference plasma dilutions, controls and samples must be added to the microwells within a five minute period. Batch size of samples should not be larger than the amount that can be added within this time period.

8. For all incubations, the start of the incubation period begins upon the completion of reagent or sample addition.
9. Addition of all samples and reagents should be performed at the same rate and in the same sequence.
10. Incubation temperatures above or below normal room temperature (18 - 26°C) may contribute to inaccurate results.
11. Avoid contamination of reagents when opening and removing aliquots from the primary vials.
12. Do not use kit components beyond expiration date.
13. Coated microwells, conjugate, and substrate are lot specific components that should not be used with different kit lots.

Reagent Preparation

1. Wash Solution - phosphate buffered saline (PBS)/Tween 20: Measure 30 mL Wash Concentrate (33X PBS/Tween 20) and dilute to 1 liter with reagent grade water. The pH of the final solution should be 7.35 ± 0.1 . Store unused PBS/Tween 20 solution at 2 - 8°C. Discard if solution shows signs of contamination.
2. Reconstitute Reference Plasma by adding 0.5 mL reagent grade water. Swirl gently to mix. Allow to stand for 10 minutes before use for complete dissolution. Stable for 8 hours when stored at 2 - 8°C. Reconstitute appropriate control plasma following manufacturer's instructions, and store as recommended.

Assay Procedure

1. Remove any microwell strips that will not be used from the frame and store them in the bag provided.
2. Assay each reference plasma dilution in duplicate. Duplicate determinations are also recommended for patient and control samples. One well should be run as a reagent blank; sample diluent without plasma is added to the well as explained in step 6 of this section. This well is treated the same as a patient sample in subsequent assay steps. A water blank well should be included with each plate; it is to remain empty until 200 μ L of reagent grade water is added at the completion of the assay, immediately prior to reading the plate. The water blank well is to be used to zero the plate reader.
3. Using the Reference Plasma provided with the kit, prepare six reference plasma dilutions as described below:

<u>Volume Reference Plasma</u>		<u>Volume Sample Diluent</u>		<u>*Reference Level</u>
30 μ L	+	500 μ L	=	150
20 μ L	+	500 μ L	=	100
15 μ L	+	500 μ L	=	75
10 μ L	+	500 μ L	=	50
10 μ L	+	1000 μ L	=	25
10 μ L	+	2000 μ L	=	12.5
**10 μ L	+	**4000 μ L	=	*6.25

* Reference level value to be used for constructing reference curve only.

**Make one additional dilution if the assayed value of the Reference Plasma is $\approx 150\%$.

4. Prepare a 1:26 dilution of each patient sample and control plasma selected for use in Sample Diluent (blue-green solution); e.g. 20 μ L sample added to 500 μ L Sample Diluent. Mix thoroughly.
5. Add 100 μ L of the dilutions (reference plasmas x 6, patient samples and controls) to the appropriate microwells.
6. Add 100 μ L of Sample Diluent to the reagent blank well. Leave the water blank well empty.

7. Incubate 15 minutes at room temperature. After the incubation is complete, carefully invert the microwells and dump the fluid. Do not allow samples to contaminate other microwells.
8. Wash 4 times with working wash solution (PBS/Tween 20). Each well should be filled with wash solution per wash. Wash solution in the empty well intended to serve as a water blank will not interfere with the procedure. Invert microwells between each wash to empty fluid. Use a snapping motion of the wrist to shake the liquid from the wells. The frame must be squeezed at the center on the top and bottom to retain microwell modules during washing. Blot on absorbent paper to remove residual wash fluid. Do not allow wells to dry out between steps.
9. Add 100 μ L HRP-Conjugated Antibody Solution (red) to each well (except the water blank well).
10. Incubate for 15 minutes at room temperature. After the incubation is complete, carefully invert the microwells and dump the conjugate solution.
11. Wash 4 times with working wash solution (PBS/Tween 20) as in step 8. Wash solution in the water blank well will not interfere with the procedure. Use a snapping motion to drain the liquid, and blot on absorbent paper after the final wash. Do not allow the wells to dry out.
12. Add 100 μ L Substrate to each well (except for the water blank well) and incubate for 10 minutes at room temperature. Add the substrate to the wells at a steady rate. Blue color will develop in wells with positive samples.
13. Add 100 μ L Stopping Solution (0.36 N sulfuric acid) to each well (except for the water blank well) to stop the enzyme reaction. Be sure to add Stopping Solution to the wells in the same order and at the same rate as the Substrate Solution was added. Blue substrate will turn yellow and colorless substrate will remain colorless. Do not add Stopping Solution to the water blank well. Instead, add 200 μ L reagent grade water to the water blank well. Blank or zero the plate reader against the water blank well. Read the O.D. of each well at 450 nm, against a 650 reference filter (if available). For best results, the O.D. values should be measured within 30 minutes after the addition of Stopping Solution.

RESULTS

1. Calculate the mean O.D. values for the duplicates of the reference plasma dilutions, controls selected for use, and patient samples.
2. Plot the mean O.D. obtained for each dilution of the reference plasma (x axis) against the corresponding value of the reference level (y axis). The curve may be plotted on a linear, semi-log or log-log graph. Draw a line to connect the points.
3. Using the mean O.D., determine the control and patient relative values from the graph, or alternatively, use linear regression to calculate from the reference curve.
4. To calculate vWF:Ag levels in percent (%) of normal, multiply the control and patient relative values (obtained from the reference curve) by the assigned value for the REAADS Reference Plasma (see vial label).

For example: Patient relative value (from the reference curve): 40
 Reference Plasma assigned value (from vial label): 105% of normal
 Actual patient vWF:Ag value (as % of normal): $40 \times 1.05 = 42\%$
5. Ensure that all quality control parameters have been met (see Quality Control) before reporting test results.

QUALITY CONTROL

1. The mean O.D. of the reagent blank should be less than 0.1 when the spectrophotometer has been blanked against the water well. Readings greater than 0.1 may indicate possible reagent contamination or inadequate plate washing.
2. O.D. values for the duplicates of the controls or patient samples should be within 20% of the mean O.D. value for samples with absorbance readings greater than 0.200.
3. vWF:Ag values obtained for the controls should fall within manufacturer's assigned ELISA ranges. Occasional small deviations outside these ranges may be acceptable.
4. Each laboratory should periodically determine their own reference range for this assay.

EXPECTED VALUES¹⁰

Normal Range: Plasma vWF:Ag values are generally expressed in relative percent (%) as compared to pooled normal plasma. The normal range when normal plasma samples were tested by REAADS vWF:Ag assay was 47 - 197% (mean 105.8%, SD 39%). This range is consistent with that published in the literature⁴⁻⁷ and reported by other commercially available assays (50-160%). Samples with values above the range of the reference curve may need to be diluted and retested for accurate results.

PERFORMANCE CHARACTERISTICS¹⁰

Detection range:

The detection range for REAADS vWF:Ag assay has been determined to be 5 - 200%. However, the effective range of each run will depend on the assayed value of the reference plasma. For greatest accuracy, samples which generate absorbance readings outside the O.D. range of the reference curve should be retested at an appropriate dilution.

Precision:

Intra-assay precision:

To determine variability within a plate, three plasma samples with known vWF levels (one high, one medium, and one low) were tested in 16 wells by two operators, on six plates from each of three lots. The data, presented in the following table, shows a mean CV of 3.6% across three lots. In addition, ninety-nine (99) patient samples with vWF levels ranging from 54 - 276% of normal were tested in duplicate across 3 lots to demonstrate the precision end users may expect when performing the assay according to package insert instructions. As shown in the table, the overall mean CV for duplicates was 2.5%.

Inter-assay precision:

Ten (10) commercially prepared, assayed plasma samples with vWF values ranging from 57 - 159% were tested in duplicate on three lots to determine assay precision between lots. The mean inter-assay CV was 5%, as seen in the table:

Intra-assay precision (variability within a plate)	vWF range (% of normal)	CV range (3 pilot lots)	Overall mean CV:
Replicates (x16):	149% - 155%	1.9 - 7.9%	
	75% - 89%	2.2 - 7.7%	
	57% - 83%	1.8 - 9.9%	3.6%
Duplicates:	54% - 276%		2.5%
Inter-assay precision (variability between lots)			
Duplicates:	57% - 159%	3.0 - 12.1%	5.0%

Linearity:

Serial two-fold dilutions of vWF reference plasma samples tested on three lots of REAADS vWF:Ag assay demonstrated curves with a mean coefficient of determination (r-squared) of 0.995; individual point recovery ranged from -10.7% to +14.0%.

Accuracy:

Accuracy was determined by testing mixtures of reference plasma with predetermined values on REAADS vWF:Ag assay and calculating the recovery of theoretical values. The overall mean percent recovery across 3 lots was 103.6% with an average variation of 5.7%.

LIMITATIONS OF THE TEST

The vWF:Ag levels obtained from this assay are an aid to diagnosis only. Each physician must interpret these results in light of the patient's history, physical findings, and other diagnostic procedures. There is a normal plasma fluctuation of vWF:Ag due to unknown mechanisms. For this reason, repeat testing may be necessary. In addition, vWF:Ag acts as an acute phase reactant; it may be increased in various stressful conditions and diseases including pregnancy, oral contraceptives, surgery, liver and autoimmune diseases, prostate cancer, etc.^{4,5}

Plasma samples can be inadvertently depleted or degraded of vWF:Ag by improper collection or laboratory processing. Individuals with "O" blood type have been shown to have lower plasma levels of vWF:Ag (\approx 25%) when compared to those with other blood types. Acquired von Willebrand disease has been reported in some patients with lymphoproliferative disease.⁷

As with any assay employing antibodies from an animal source (e.g. mouse, rabbit, goat, etc.) to capture a target molecule, the possibility exists for interference in the serum or plasma of patients who have been exposed to preparations containing animal antibodies for diagnosis or therapy. Falsely elevated or depressed values may be seen in these patients.

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Warranty

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