Thromboelastogram (TEG) Procedure # 1679

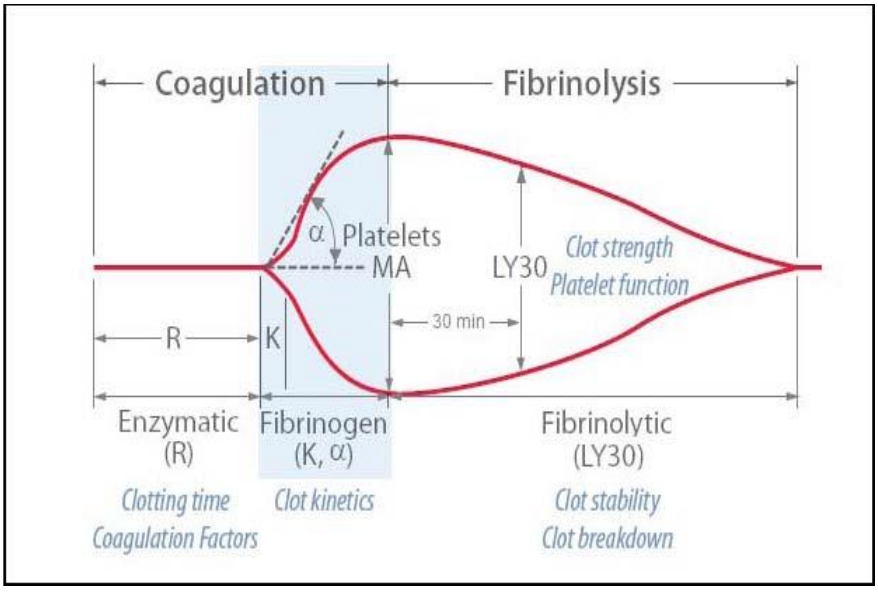
PRINCIPLE

Thromboelastography is a method for measuring the viscoelastic properties of clotting blood or plasma. The TEG analyzer includes a sample cup that oscillates constantly at a set speed through an arc of 4°45'. The cup, containing a blood or plasma sample, and a stationary pin attached to a torsion wire is immersed in the sample. Once initiated, the cup rotates back and forth at 10 second intervals. When the first measurable clot forms, it begins to bind the cup and pin, causing the pin to oscillate in phase with the cup. The rate of increased movement of the pin is a function of clot development and is graphically displayed.

The torque created by fibrin-platelet bonding that links the cup and pin together is transmitted to the immersed pin. Increased strength of the generated fibrin-platelet bonds translates to increased magnitude of pin motion, which is directly related to the strength of the formed clot. If lysis occurs, some bonds are broken and the degree of pin motion is diminished. The degree of rotational movement by the pin is converted by a mechanical-electrical transducer to an electrical signal which is monitored by a computer then converted into a graphical tracing that reflects the hemostasis profile of clot formation.

The resulting hemostasis profile is a measure of the time it takes for the first measurable clot to be formed (R), the kinetics of clot formation (Angle or α and K), the strength of the clot (Maximum Amplitude or MA) and the breakdown of the clot, or fibrinolysis (LYS30) at 30 minutes after MA is reached.

1. R: Reaction time
2. K: K-time
3. α: Angle
4. MA: Maximum Amplitude
5. LY30: Percent Lysis 30 minutes after MA



EQUIPMENT, REAGENTS AND SUPPLIES

1. TEG 5000 analyzer, related software and dedicated computer
2. Pipets capable of dispensing 20µL and 340µL with related disposable tips
3. TEG Controls, Level I (REF 8001) and Level II (REF 8002)
    a. Stored at refrigerated temperatures (2-8^{o}C)
4. TEG Kaolin reagent (REF 6300)
    a. Stored at refrigerated temperatures (2-8^{o}C)
5. Disposable 1.0ml transfer pipets

SAMPLE REQUIREMENTS

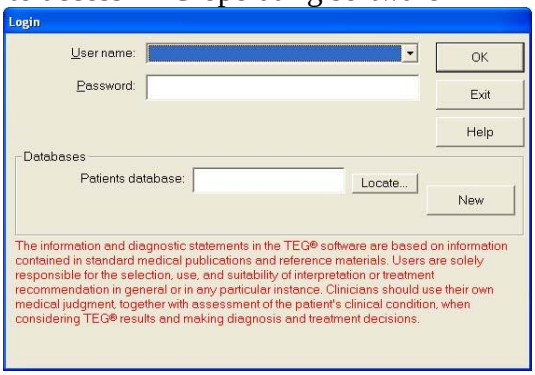
Only 3.2% sodium citrate samples are acceptable for testing. Although native whole blood is commonly used, the reference ranges noted in analyzers are for citrated blood.

Once collected, the sample should equilibrate at room temperature for at least 15 minutes, but testing must be completed within two hours of collection.

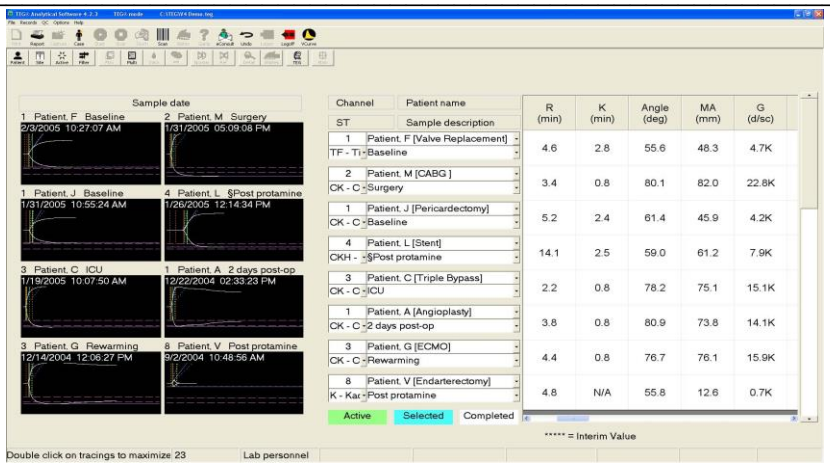
DAILY MAINTENANCE

Prior to each day of use, the instruments require an electronic check. Even though only a single device may only be for a single test, the daily maintenance is to be performed on both devices concurrently.

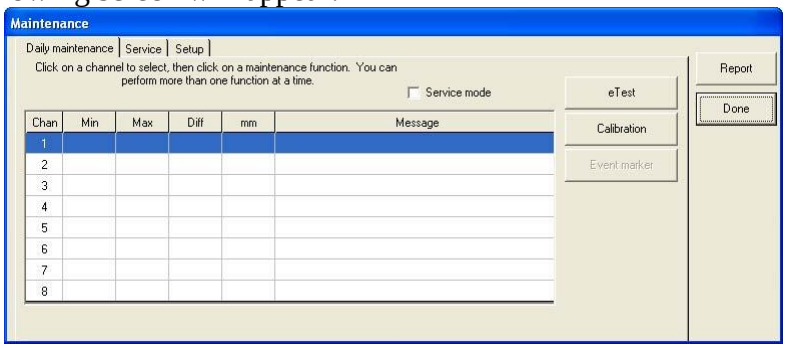
1. Turn on TEG and PC
2. Open TEG software from desktop icon
3. Accept default login (Site Administrator) and enter "teg" (must be lowercase) for password to access TEG operating software



4. Next pop-up box is for individual login or default login (Temporary logon)
5. The main screen will appear:



6. Check level on top of instruments to be sure they are level:
   a. Bubble should central and within etched circle
   b. If not, adjust using screw legs to position bubble centrally.
   c. DO NOT proceed with maintenance or patient testing until instruments are level.
7. At task bar along top of screen, select “Options”, the “Maintenance”.
8. The following screen will appear:



8. Select a row for a connected channel and click eTest. Repeat for all connected channels. On the analyzer(s), move the levers to Test.
   a. Check the Min and Max fields to make sure the values that display fall between the acceptable range of 1800 and 2300. The ideal reading is between 1950 and 2050.
9. Check that the Message field for both channels reads eTEST value is OK.
10. Print and select “Done” when complete.

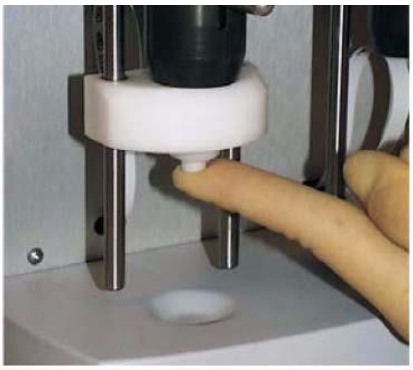
QUALITY CONTROL

Two levels of controls are required for every 24 hours of operation. The instrument will also provide alert by pop-up message when QC is due.

QC limits are provided with each lot number. These limits and lot numbers are to be entered into the TEG software in order for QC graphs to be accurately displayed. Refer to Operator's manual for implementing and entering new QC lot numbers and corresponding limits (Chapter 11).

1. Reconstitute Level I and II controls:
    a. For level I, transfer entire contents of green vial (diluent) into blue vial
    b. For level II, transfer entire contents of green vial (diluent) into yellow vial
    c. Shake vigorously for about 10-15 seconds
    d. Allow to stand at room temperature for 5 minutes.
    e. Shake vigorously for about 10-15 seconds
2. Load a cup and pin onto the TEG analyzer. Assure instruments are level
    a. Slide the carrier down to the platform, with the lever in the Load position.
    b. Place a disposable cup, with the pin inside it, into the cupwell.
    c. Carefully slide the carrier all the way up until it is flush with the bottom of the column. Make sure the pin stays upright in the cup so that it can fit over the tip of the spindle. **Stabilize instrument by holding top portion of device while loading cup/pin**
    d. Press upward on the pusher at the bottom of the carrier while using your other hand to apply counter-pressure to the top of the analyzer. This loads the pin on the spindle.
    e. Slide the carrier back down and push the cup firmly into the cupwell. When the cup is seated correctly, the flange of the cup touches the top of the carrier.





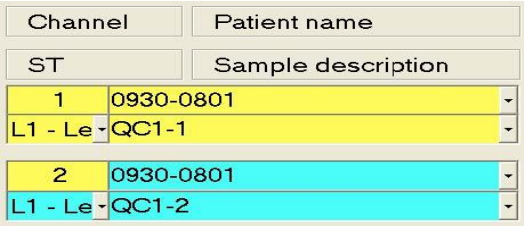
3. From Main Menu, In the TAS Main screen, 

icon.

4. Complete the following fields in the two channel sections that correspond to the analyzer:

Field	Action
Channel	This field is pre-filled with the channel number that corresponds to the column on the analyzer.
ST (Sample Type) (Required)	From the drop-down list, select "L1 – Level I control or L2 – Level II control"

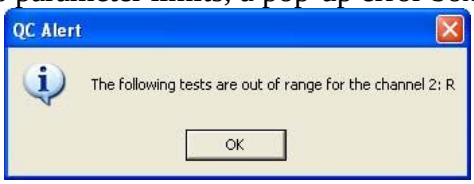
NOTE: Level I and Level II quality control samples must be run on each channel on the TEG analyzer. For each TEG analyzer that you are testing, you need to prepare one vial of Level I control and one vial of Level II control.
NOTE: One vial of control will have adequate volume for 3 channels.
An example of an ordered QC for channels 1 and 2 of a TEG analyzer:



5. Add 20µL of provided 0.2M calcium chloride to each cup.
6. Pipette 340µL of reconstituted Level I control into each cup.
    a) Stabilizing instrument by holding top portion of device, with other hand quickly but carefully raise the carriers until they are flush with the bottom of each column.
    b) Move the levers to Test.
    c) In the TEG screen, select the first channel then press F10
    d) Repeat for second channel
7. To view the results, click Done to return to the TAS Main screen
8. Allow the control samples to run approximately 15 to 20 minutes until the MA is defined in the software (that is, no asterisks appear next to the value).
9. From the TAS Main screen or the TEG screen, select the first channel to stop by pressing F11.
10. Click Yes in the confirmation message that displays. The channel turns white, indicating that the sample is terminated.
11. Repeat steps 12 and 13 to stop the next channel.
12. Move the levers from Test to Load position. Eject pin and cup.
    a) Press the lever down to the Eject position.
    b) Slide the carrier down and ensure that the pin has dropped into the cup.
    c) Press the carrier down firmly against the platform so that the plastic pusher located at the bottom of the carrier pushes the cup and pin out of the cupwell.
    d) Remover and dispose of cup/pin in appropriate waste container
13. Repeat steps 2-12 for Level 2 QC

14. Parameters (R, K, etc) display in real time as the sample is running. Parameters with numerical values with "*****" indicate preliminary results, while parameters with just numerical values are final results.

When QC exceeds parameter limits, a pop-up error box will appear:

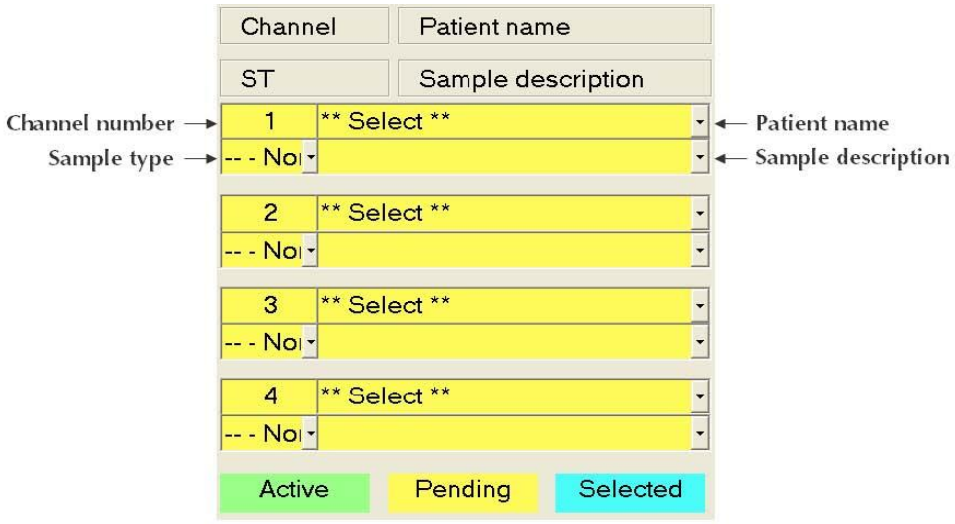


1. In the QC Alert message that displays when a parameter is out of range, click OK.
2. In the Corrective action screen, enter a description of the action(s) you will take to obtain satisfactory results.
3. Common causes for QC failure are:
    a. Unsatisfactory reagent reconstitution
        i. Poor mixing
        ii. Inadequate time to allow QC to dissolve
4. First option for failed QC is reconstitution of new material and repeat testing.
    a. If QC fails again, this could represent mechanical problems.

PROCEDURE

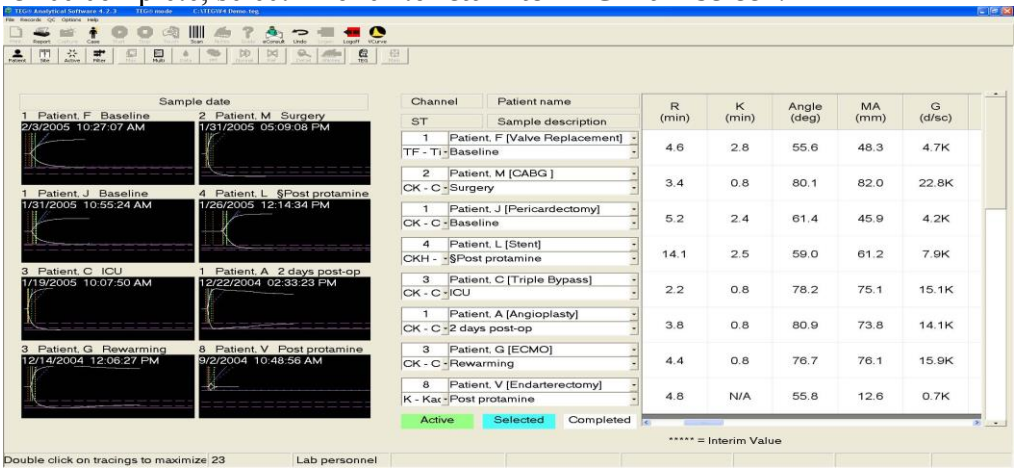
1. Prepare instrument (see Maintenance section) and run QC as necessary
2. Assure instrument(s) is level
3. Load a cup and pin onto the TEG analyzer.
    a. Slide the carrier down to the platform, with the lever in the Load position.
    b. Place a disposable cup, with the pin inside it, into the cupwell.
    c. Stabilize instrument by holding top portion of device while loading cup/pin, then carefully slide the carrier all the way up until it is flush with the bottom of the column. Make sure the pin stays upright in the cup so that it can fit over the tip of the spindle. Press upward on the pusher at the bottom of the carrier while using your other hand to apply counter-pressure to the top of the analyzer. This loads the pin on the spindle.
    d. Slide the carrier back down and push the cup firmly into the cupwell. When the cup is seated correctly, the flange of the cup touches the top of the carrier.
4. From Main Menu, In the TAS Main screen, click 

icon.
5. Complete the following fields in the channel sections that correspond to the appropriate TEG analyzer:

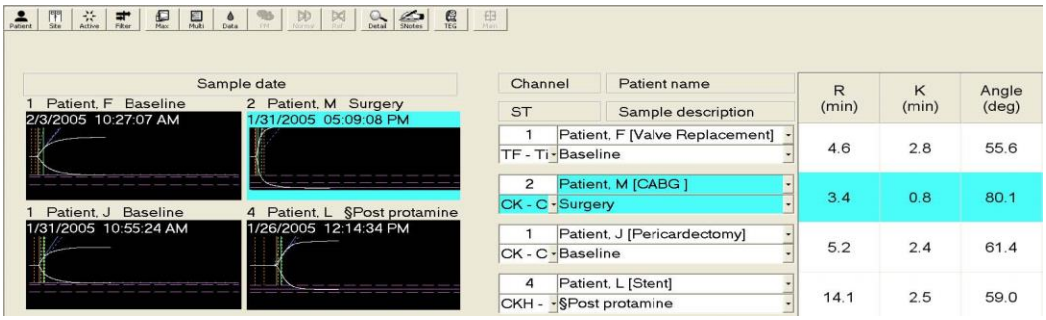


NOTE: For new patient data entry into "Patient Name", there will be a pop-up box that that a new patient requires additional data entry…only MR# or patient name (which ever is not used as the primary identifier) is required. Sample type is Citrated Kaolin.

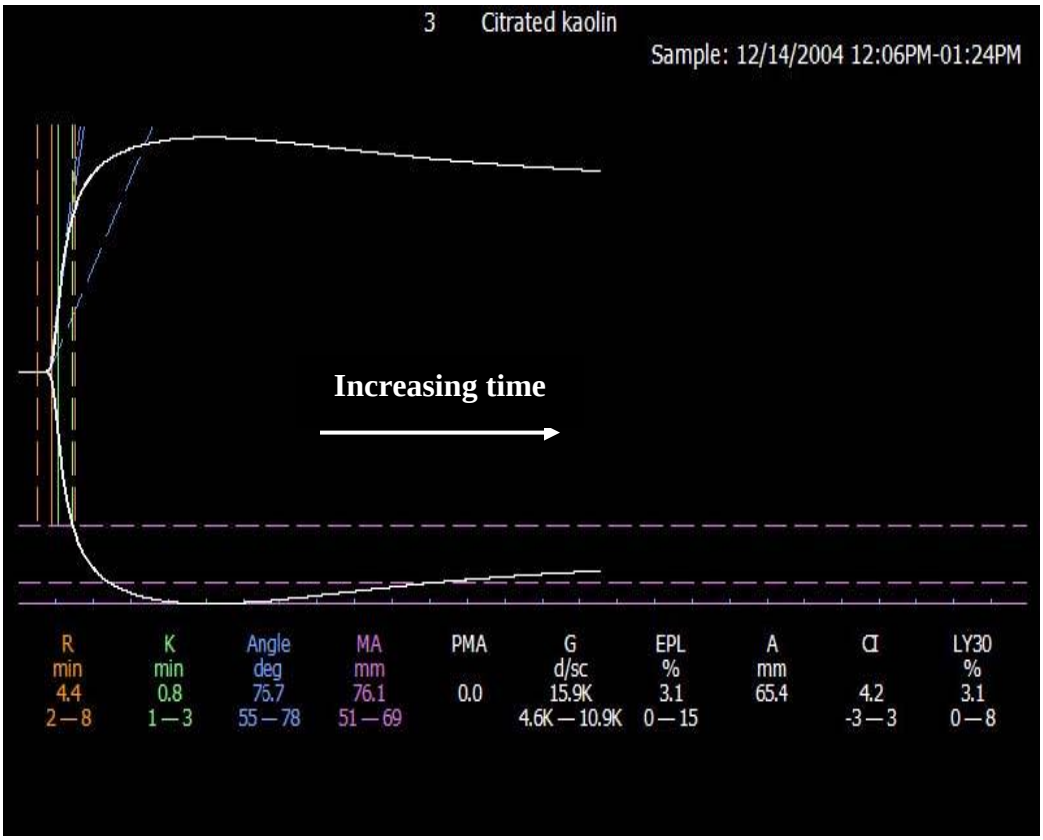
6. Add 20µL of provided 0.2M calcium chloride (from Kaolin vial box) to each cup.
7. Using plastic transfer pipet, add 1.0ml of citrated whole blood to Kaolin vial.
8. Quickly pipette 340µL of kaolin enriched whole blood to into cup(s).
9. Stabilizing instrument by holding top portion of device, with other hand quickly but carefully raise the carriers until they are flush with the bottom of each column.
10. Move the levers to Test.
11. In the TEG screen, select (highlighted blue)the appropriate channel, then press F10. Once the sample has been started, it will be backlit green indicating testing in progress. When selecting a sample that is currently running, the green "ACTIVE" icon will flash.
12. Repeat for second channel.
13. Once complete, select "Done" to return to TEG main screen:



14. Parameters (R, K, etc) display in real time as the sample is running. Parameters with numerical values with "*****" indicate preliminary results, while parameters with just numerical values are final results.
15. Allow the test to continue to run until LY60 is complete (approximately 70-90 minutes from start of test).
16. Once testing is complete, highlight sample, then press F11 to stop testing.
17. Print results using print icon from task bar



TEG TRACINGS (view mode)



Parameter
Units
Result
Normal range

Color coding on parameters corresponds to colored lines on graph

REPORTABLE TEG RESULTS

R or R-time (Reaction time): The time from the start of a sample run until the first significant levels of detectable clot formation (amplitude = 2 mm in the TEG tracing). This most represents the enzymatic portion of coagulation. R-time is prolonged by anticoagulants and factor deficiencies and shortened by hypercoagulable conditions.

K or K-time: Achievement of a certain clot strength. K is a measure of the time from R until a fixed level of clot strength is reached (amplitude = 20 mm). This most represents initial clot kinetics. K is shortened by increased fibrinogen level and, to a lesser extent, by increased platelet function, and is prolonged by anticoagulants that affect both. If the amplitude does not reach 20 mm, K is undefined. **NOTE**: If the MA of the sample is less than 25 mm, do not use K for clinical decisions. In these samples, use angle.

Angle (α): Measures the rapidity of fibrin build-up and cross-linking (clot strengthening). This mostly represents fibrinogen level. Angle relates to K, since both are a function of the rate of clot formation. Angle is more comprehensive than K, since there are hypocoagulable conditions in which the final level of clot strength does not reach an amplitude of 20 mm (in which case K is undefined). Similar to K, Angle is made larger by increased fibrinogen levels and, to a lesser extent, by increased platelet function, and is decreased by anticoagulants that affect both.

MA, or Maximum Amplitude: A direct function of the maximum clot strength. In tests where platelets are part of the clot, this parameter most reflects platelet function/aggregation. Clot strength is the result of two components - the modest contribution of fibrin and the much more significant contribution of the platelets. Approximately 80% of the contribution to MA is from platelets, and the remaining 20% from fibrin. This remaining 20% is the only component measured by the traditional PT and aPTT tests.

LY30 and LY60: Percent lysis 30 and 60 minutes (respectively) after MA is reached. The LY measurement is based on the reduction of the area under the TEG tracing from the time MA is measured until 30 and 60 minutes after the MA.

REFERENCE RANGE:
For citrated whole blood using kaolin activation:

R: 5 – 10 minutes
K: 1 – 3 min
Angle: 53 – 72 degrees
MA: 50 – 70mm
LY30: < 5.5%
LY60: <7.5%

RESULT REPORTING

Only R, K, Angle, MA, LY30 and LY60 will be reported in LIS. Interpretation of data should accompany each result (see appendix for canned text comments)

CRITICAL VALUES

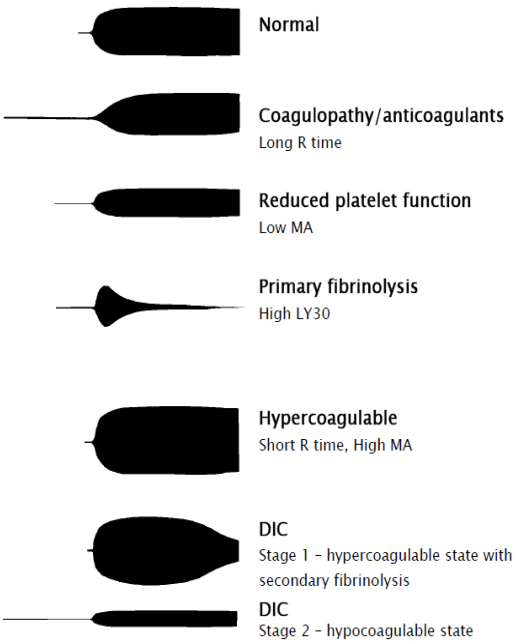
There are no critical values for this test

RESULT INTERPRETATIONS

Interpretation of TEG tracings must be performed in conjunction with patient's clinical presentation, medication history, transfusion history, etc.

Classic TEG abnormalities:

- Prolonged R – factor deficiencies or drug effect (e.g. heparin, thrombin inhibitors)
- Shortened R – hypercoagulability
- Reduced K or increased angle – increased fibrinogen
- Reduced MA – decreased fibrinogen and platelet function
- Increased MA - hypercoagulability
- Increased LY30 or LY60 – accelerated fibrinolysis



LIMITATIONS AND INTERFERENCES

- Internal studies have demonstrated that kaolin or non-kaolin activated TEG is not sensitive to anti-platelet drugs nor adequately assessing platelet function.
- The TEG analyzer must be level. A leveling bubble and leveling feet are built into the instrument.
- The TEG analyzer is sensitive to vibration and must be set up so that vibrations and jolting are avoided.
- Testing sensitivity of the TEG analyzer is affected if the following environmental specifications are not met:
    - Operating temperature must be between 15°C to 30°C. Storage temperature is from –30°C to 50°C. Mains supply fluctuations not to exceed ±10% of the nominal voltage. Maximum relative humidity is 80%. Over-voltage Category II. □
- The maximum oscillation of the cup in the TEG instrument is approximately 5 degrees, as described in the Interference section below. Therefore, the maximum amplitude (MA parameter) cannot be measured beyond 96 mm.
- The eTest value of the TEG instrument determines the zero starting point of the graphical output tracing. Therefore, out of range conditions may prevent the TEG graph from reaching its maximum amplitude (the MA parameter may not reach its maximum value). The software issues a warning if the eTest value is out of range when a sample is started.
- As with any coagulation test, the TEG can be affected by pre-analytical variables associated with blood collection, transport, and temperature.

- The TEG may not detect anti-platelet Rx, von Willebrand disease or mildly dysfunctional platelets.

Other limitations based on our evaluation:

1. The TEG R time poorly correlates with PT or aPTT, and is relatively insensitive to factor deficiencies, and should not be relied upon to detect same. A normal TEG R time does not exclude significant deficiencies, and ↑ R times are associated with factor levels of <20%.
2. The TEG k time and Angle correlate with fibrinogen levels, but ↑ k times and ↓ Angles appear to be sensitivity to fibrinogen levels <100mg%.
3. A normal TEG Angle and MA do not exclude the presence of anti-platelet drugs, or platelet function defects. The Angle and MA appear to be sensitive to thrombocytopenia (~ 100,000/mm^3).
4. The TEG Lysis30 and Lysis60 appear to detect increases in fibrinolytic activity, but the Euglobulin Lysis Time may be a more sensitive test for both ↑ and ↓fibrinolytic capacity.
5. The interpretation of the TEG should be used in concert with patient's clinical, laboratory and medication history.

INTERNAL PERFORMANCE VERIFICATION

Imprecision:

Within run using whole blood sample:

	SP	WB R	WB K	WB Angle	WB MA
Mean	6.1	6.8	2.7	56.3	57.2
SD	0.5	0.6	0.1	1.4	1.0
CV	8.6%	9.0%	4.9%	2.4%	1.8%

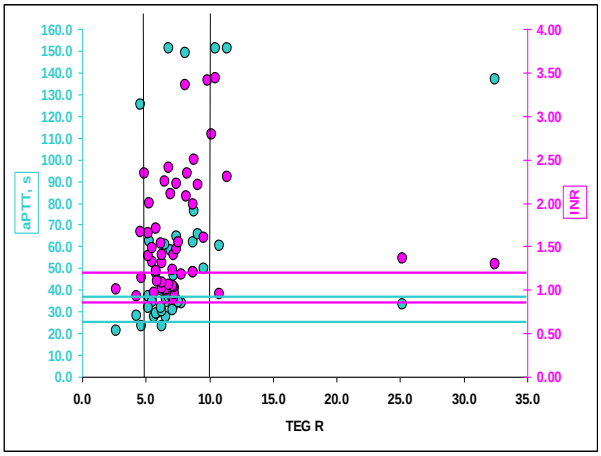
Day-to-Day using QC material:

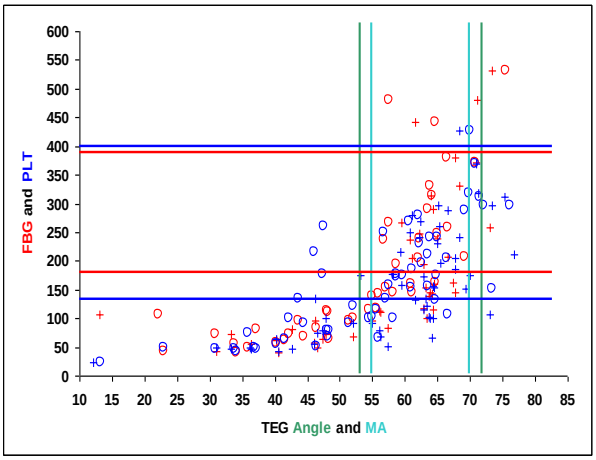
Level I N=29	R	K	Angle	MA
Mean	1.00	0.84	83.06	50.69
SD	0.24	0.02	1.37	1.93
Level II N=30	**R**	**K**	**Angle**	**MA**
Mean	2.10	1.58	70.63	32.06
SD	0.09	0.37	2.36	2.98

Reference Range:

	WB R (5 - 10)	WB K (1 - 3)	WB Angle (53 - 72)	WB MA (50 - 70)	WB Lysis30
Mean	8.3	2.2	59.6	58.2	1.4
SD	1.6	0.6	7.8	6.9	1.9
Min	4.9	1.3	34.7	44.7	0.0
Max	12.4	4.0	71.8	77.7	8.6
Low -2SD	5.1	1.1	44.0	44.4	0.0
High +2SD	11.5	3.3	75.2	72.0	5.3

Accuracy:





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Procedure History

Date	Written/ Revised By	Revision	Approved Date	Approved By
06/13	B. Gosselin	New	08/5/2013	L Howell, MD
09/01/15	B Gosselin	Modified QC parameters		