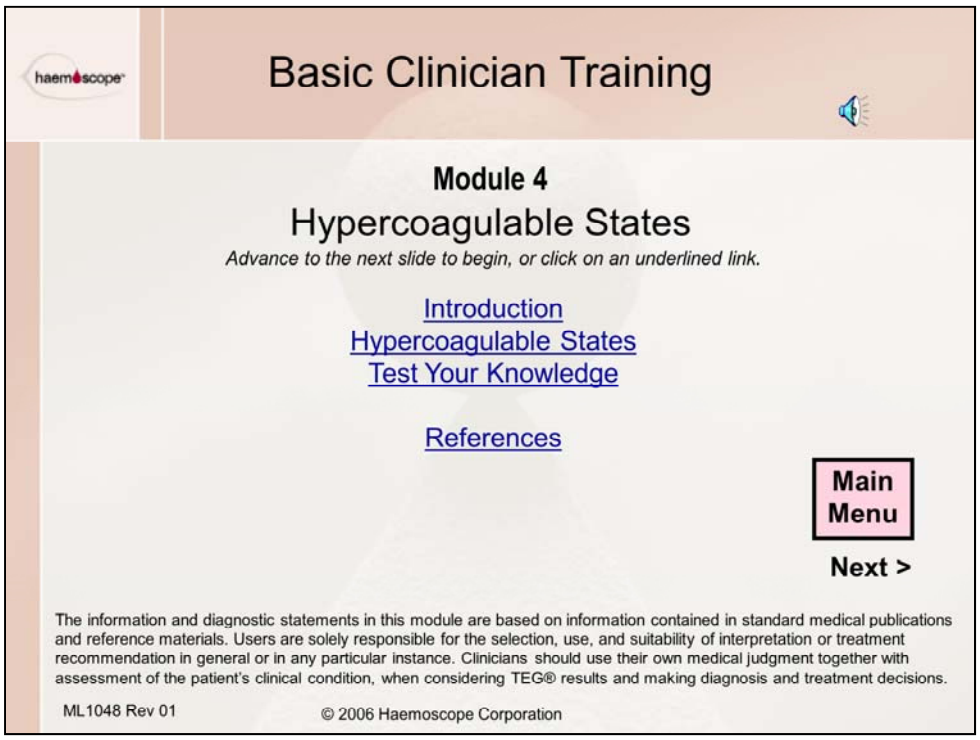
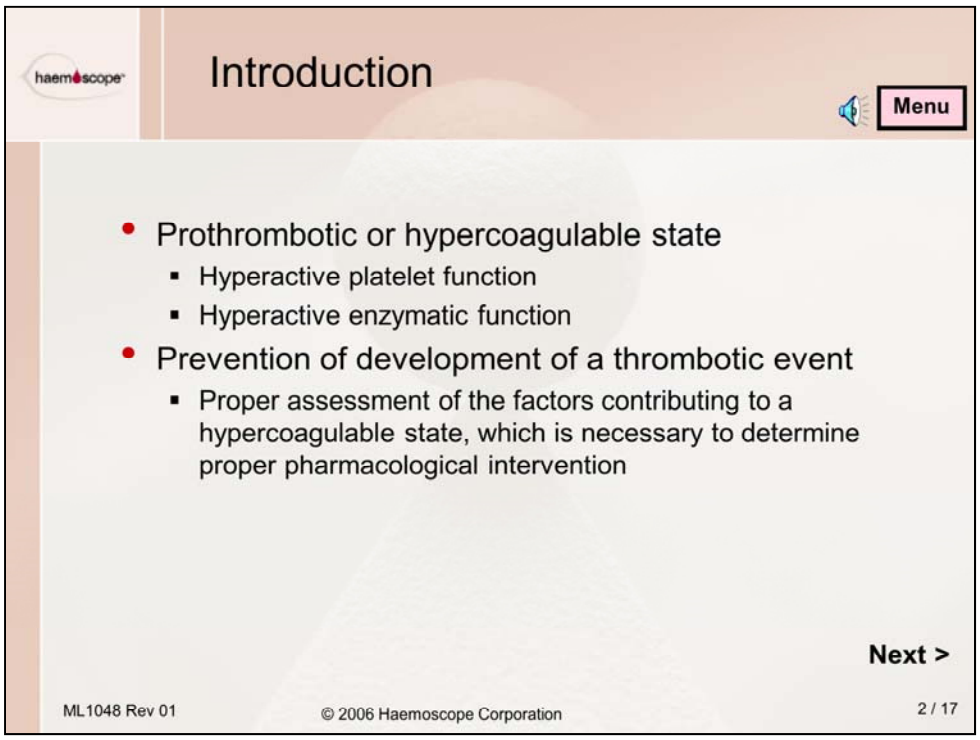


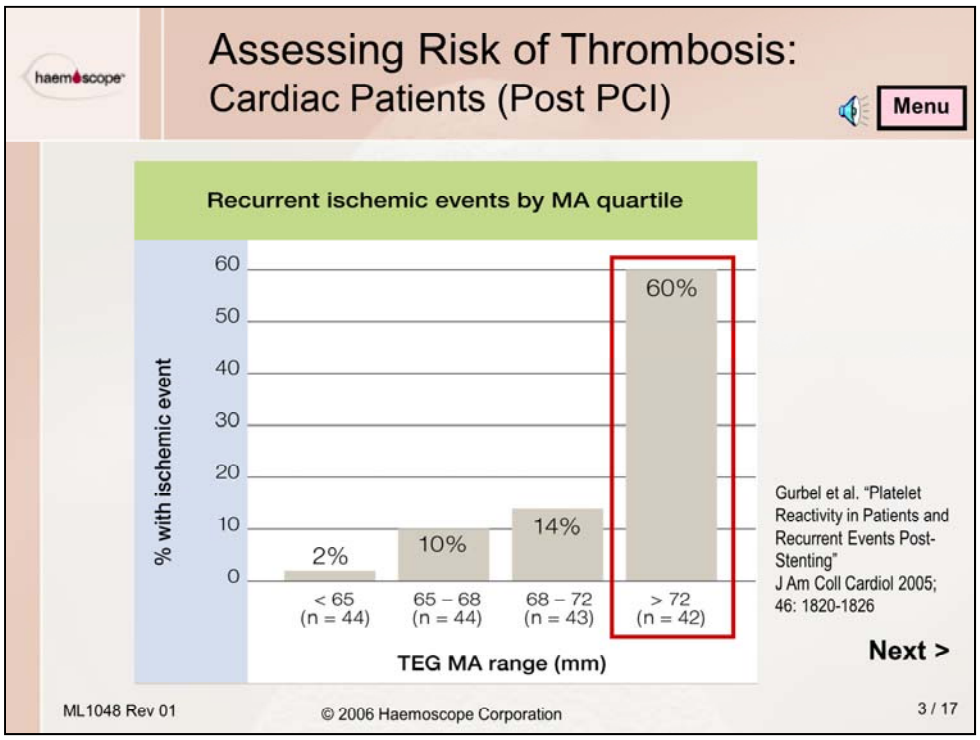

This module discusses hypercoagulable states and how the TEG analyzer can be used to determine the extent and cause of hypercoagulability.

Advance to the next slide to begin the presentation, or click on an underlined link to proceed to a specific topic



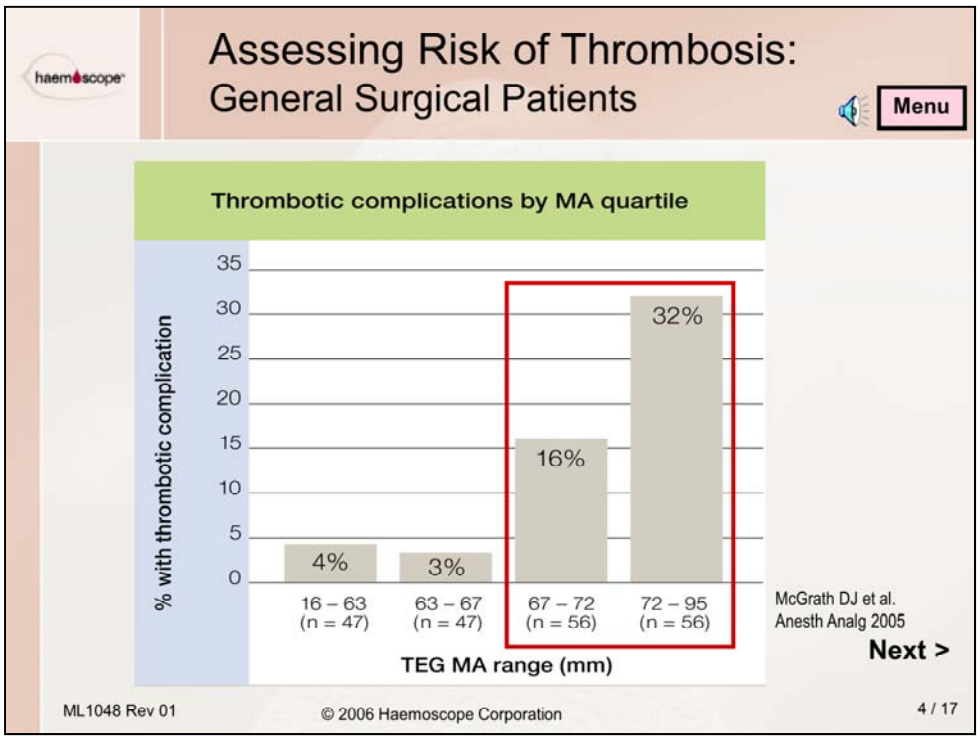

Many disease states are associated with an inflammatory condition that shifts the hemostatic balance towards a prothrombotic or hypercoagulable state, increasing the risk of a thrombotic event.

A prothrombotic state can be the result of a hyperactive platelet or enzymatic function, often due to a reduction in the activity of important negative feedback pathways in the hemostatic system. Proper assessment of the factors contributing to the prothrombotic state is necessary to determine the pharmacological intervention needed to normalize the TEG tracing.

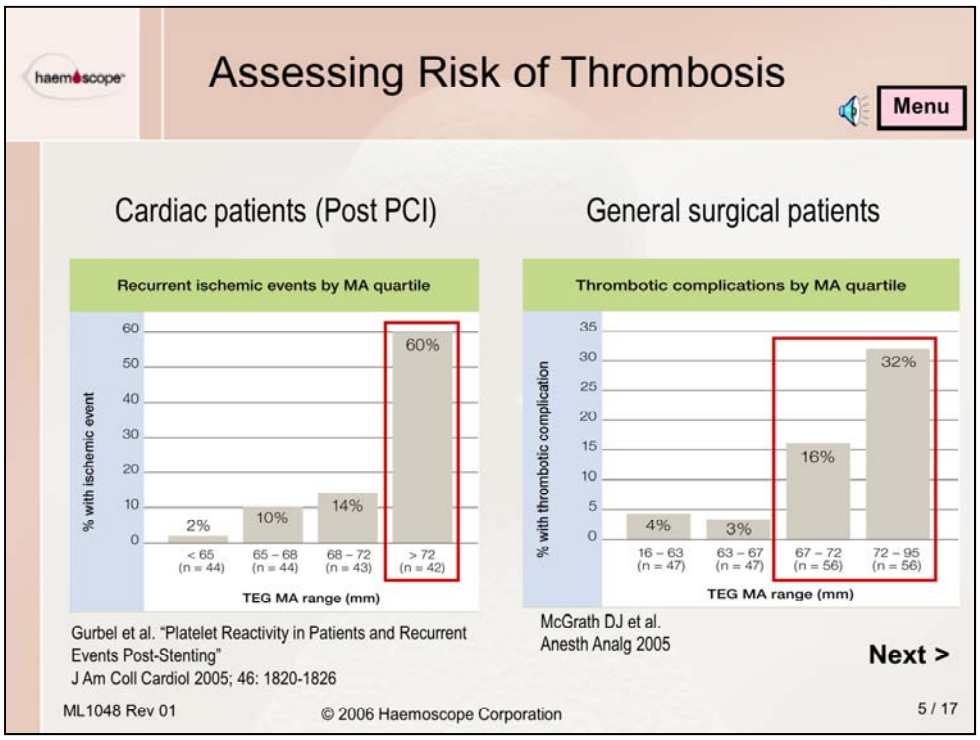



In the past, it has been difficult to assess individual risk for the development of a thrombotic event. However, the TEG analyzer is able to demonstrate both platelet and enzymatic hypercoagulability.

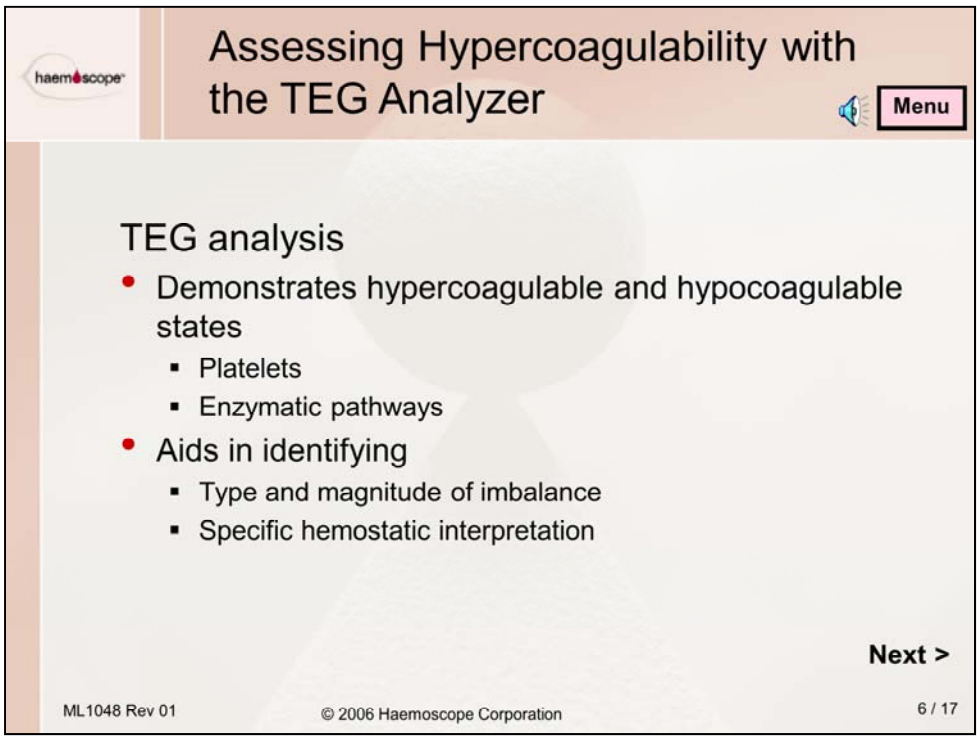
A recent study of cardiac patients used the TEG MA value, which represents clot strength, to assess the risk of ischemic events. This study demonstrated that MA values greater than 72 mm indicate a significantly increased risk of recurrent ischemic events (Gurbel 2005).



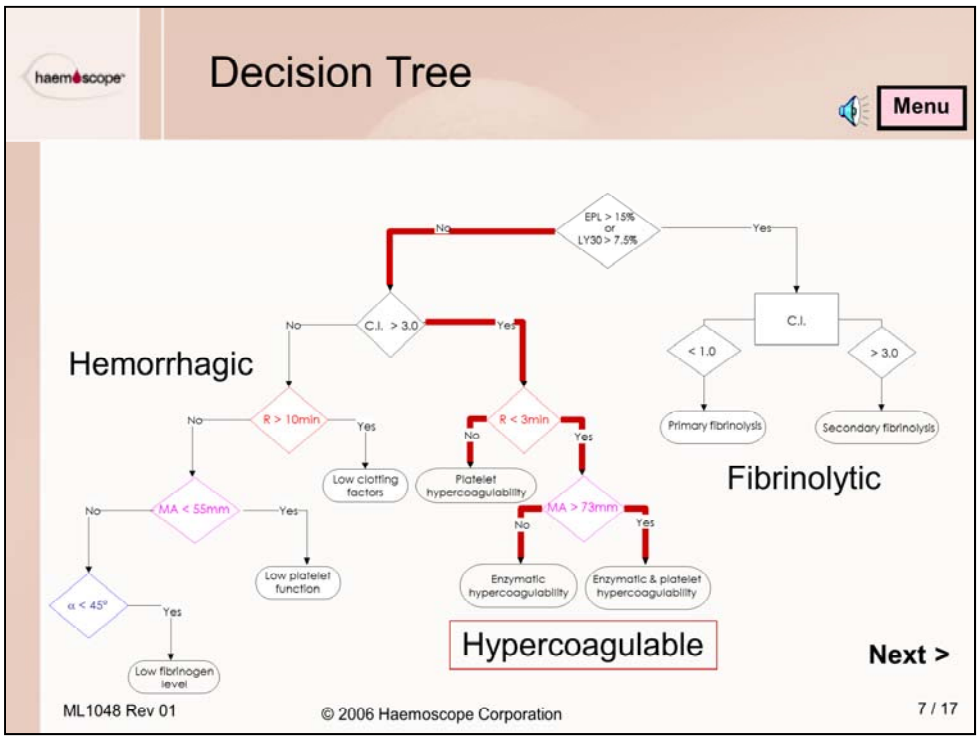

A similar study involving general non-cardiac surgical patients also used the TEG MA value to assess the risk of thrombotic complications. In this study, MA values greater than 68 mm were associated with an increase in the incidence of post-operative thrombotic events (McCrath, 2005).



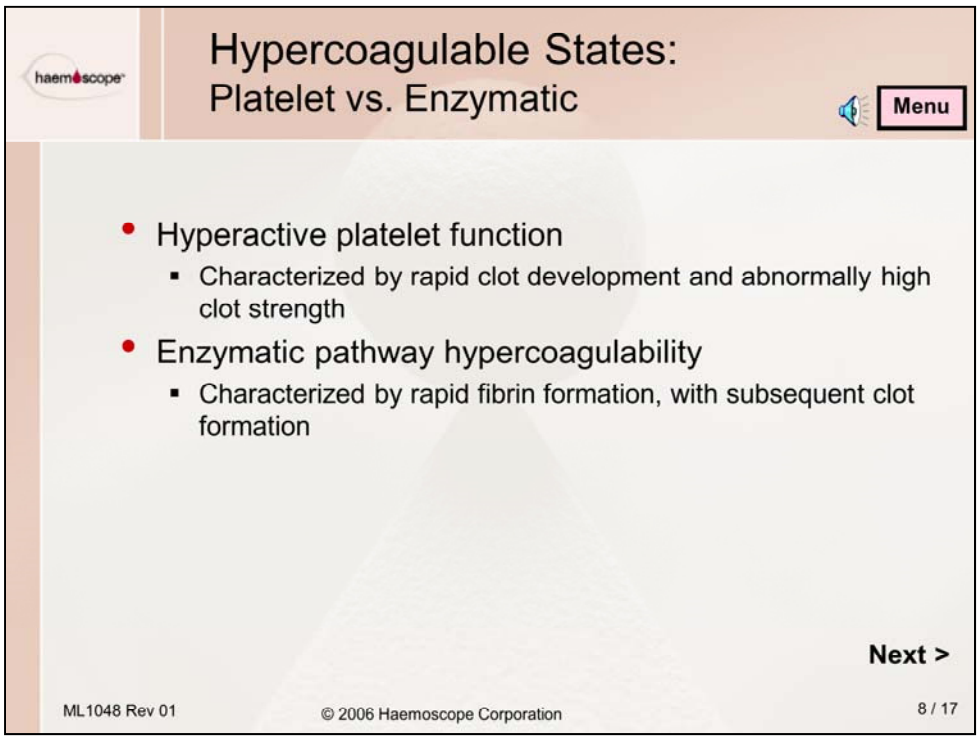

These two studies demonstrate the relationship between clot strength (MA) and thrombotic risk in a wide variety of patients.




TEG analysis is able to demonstrate the hypercoagulable as well as the hypocoagulable state for platelets and the enzymatic reaction. This makes it a useful tool in identifying the type and magnitude of hemostatic imbalance, aiding in the determination of a specific interpretation.

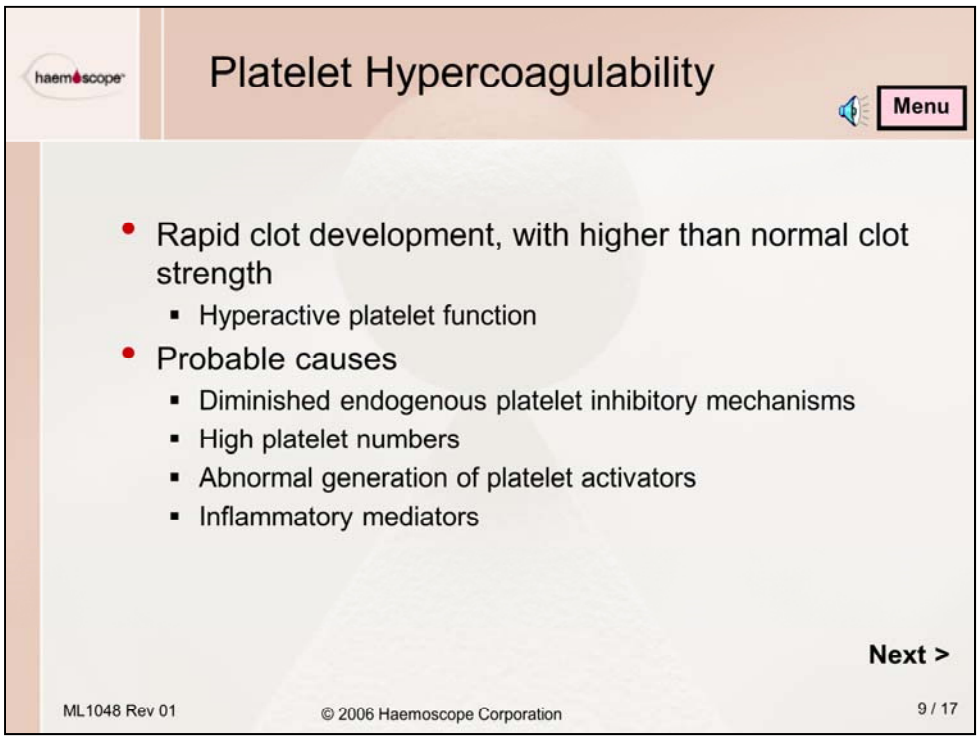



The quantitative TEG decision tree can be used to guide you in determining specific characteristics of a hypercoagulable state. If the EPL value is less than 15% or the LY30 value is less than 7.5%, and if the CI is greater than 3.0, the decision tree suggests a hypercoagulable state. It also provides more information with the R and MA values.



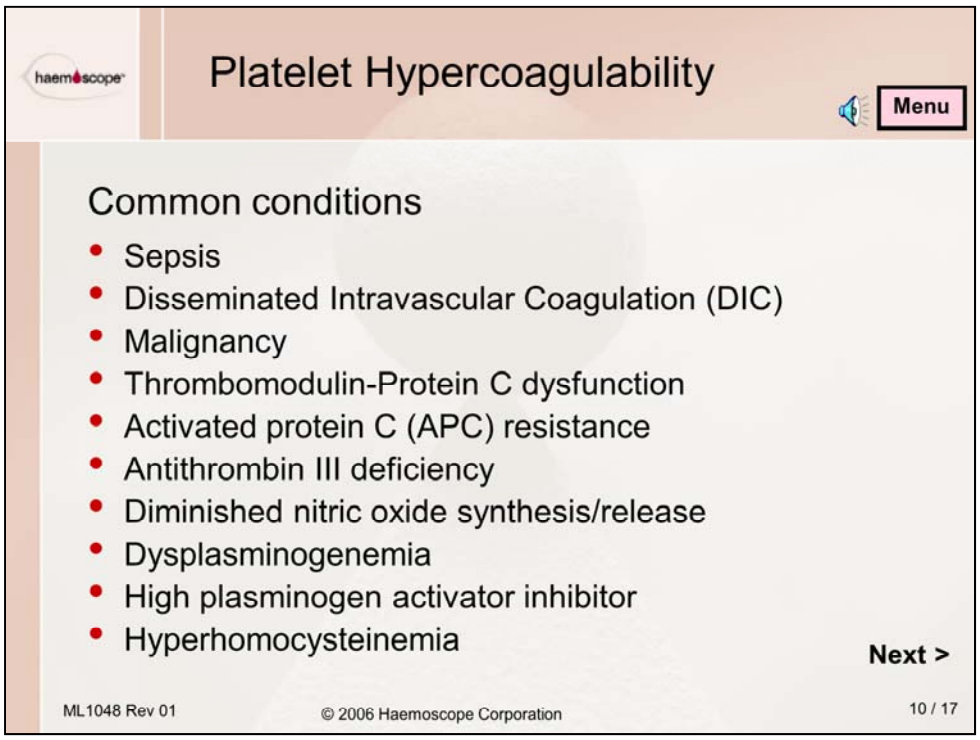

Due to the important role of platelets in the hemostatic process of clot development, several TEG parameters are affected by hyperactive platelet function. This condition is characterized by rapid clot development, producing a high angle, and abnormally high clot strength, producing a high MA.

Enzymatic hypercoagulability is typically characterized by rapid fibrin formation, producing a low R value, with subsequent clot formation, producing normal or high angle and MA values.



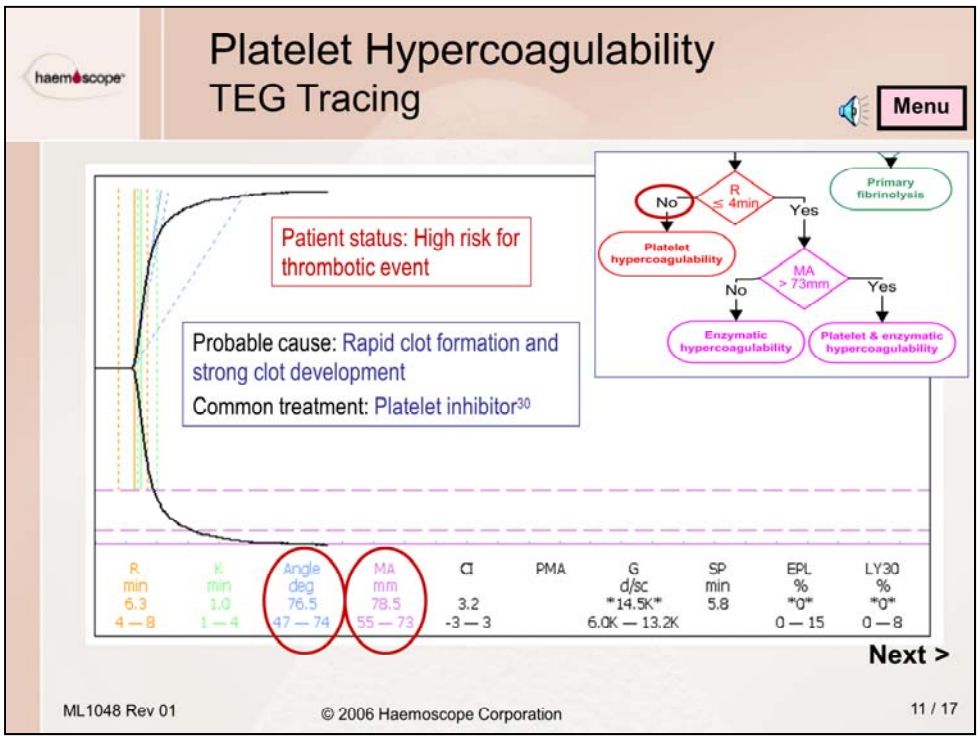

One of the probable causes of platelet hypercoagulability is diminished endogenous platelet inhibitory mechanisms, such as release of antiplatelet mediators from the vascular endothelium (i.e. nitric oxide, prostacyclin). Other probable causes include

- High platelet numbers due to stimulation of platelet production by the bone marrow
- Abnormal generation of platelet activators such as ADP, epinephrine, and platelet activating factor
- Production of inflammatory mediator cells, such as monocytes and endothelial cells, which affect the platelets directly or through the activation of other cells



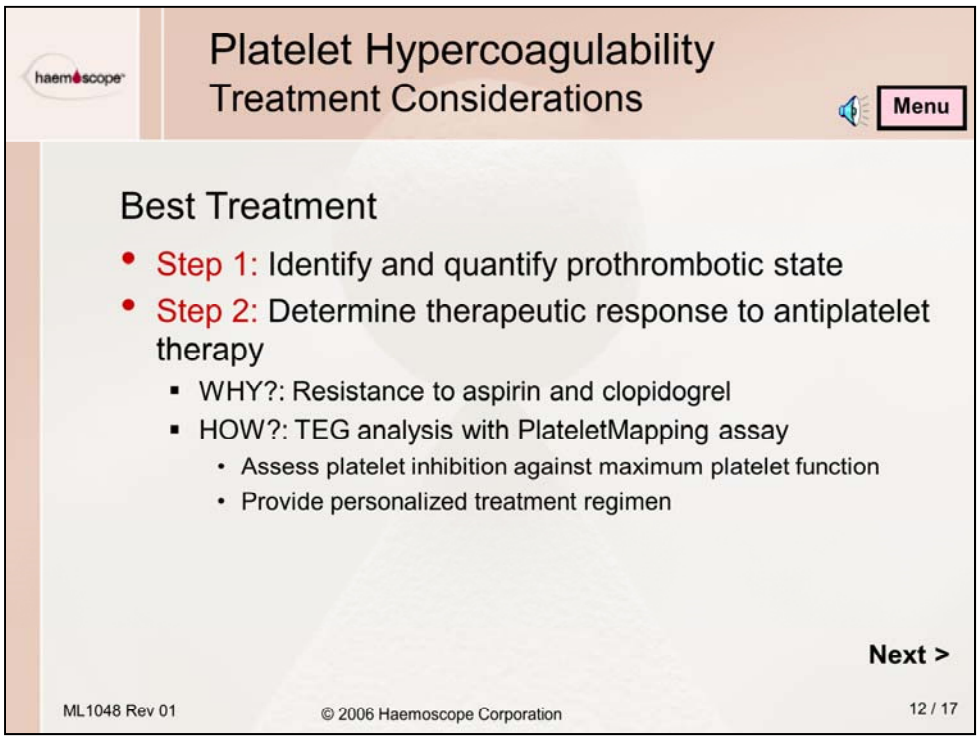

Common conditions in which platelet hypercoagulability occurs include infection or systemic inflammation such as:

- Sepsis
- Disseminated Intravascular Coagulation or DIC
- Certain types of malignancy
- Thrombomodulin-protein C dysfunction or deficiency
- Activated protein C (APC) resistance
- Antithrombin III deficiency
- Diminished nitric oxide synthesis or release by the endothelial cells
- Dysplasminogenemia, where an abnormal, inactive form of plasminogen is produced
- High plasminogen activator inhibitor (PAI-1) levels
- Hyperhomocysteinemia, where an inborn metabolic error produces an excess of homocysteine, a risk factor for coronary vascular disease




Platelet hypercoagulability appears in a TEG tracing as both rapid clot development, producing a high angle, and strong clot development, resulting in a high MA. Such a patient is at higher risk of a thrombotic event. Because of the normal R, fibrin formation appears to be in balance, and excessive thrombin generation would not be suspected.

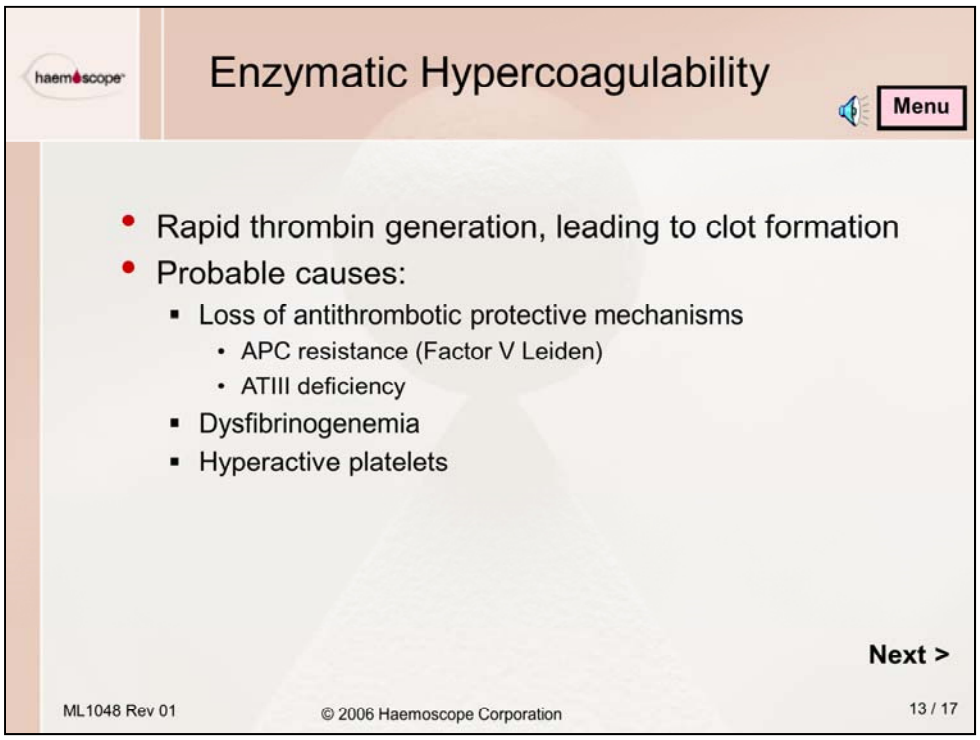
The most common treatment option for platelet hypercoagulability is administration of an antiplatelet agent.[30]




Determining the best treatment option for platelet hypercoagulability first requires identification and quantification of the prothrombotic state. TEG analysis is useful for this purpose.

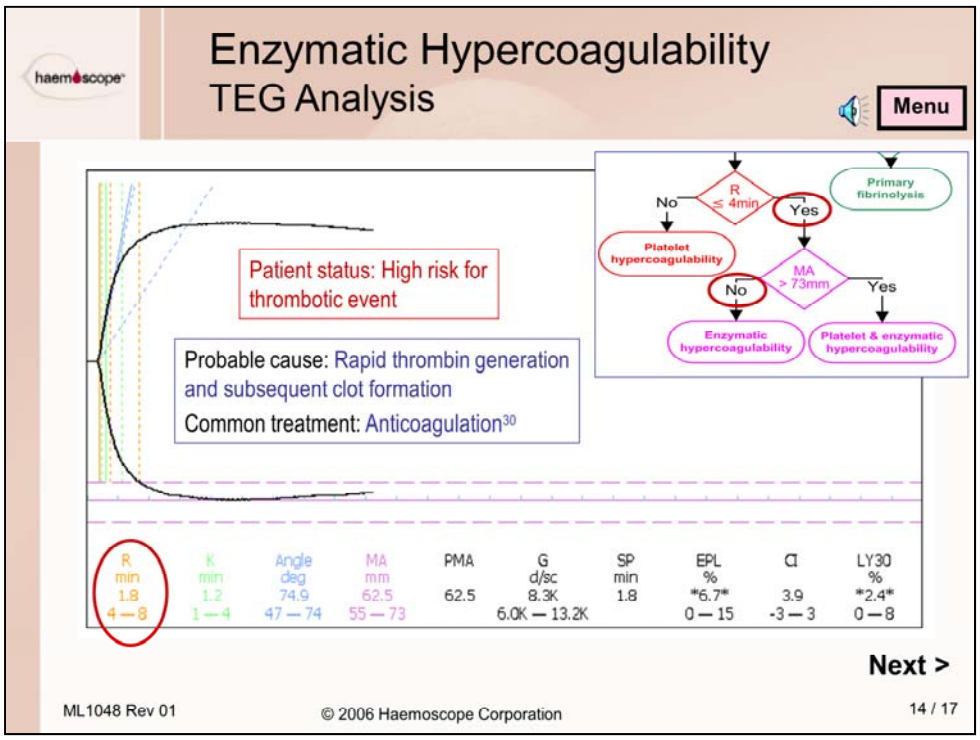
A second important step is to determine therapeutic response to anti-platelet therapy. This is essential because several studies have documented patient resistance to both aspirin and clopidogrel, the most common oral anti-platelet agents.[32, 33]

Normal TEG analysis cannot demonstrate the effect of anti-platelet agents on clot strength. However, Haemoscope has developed a PlateletMapping assay that uses the TEG analyzer to determine the extent of platelet inhibition against each patient's maximum platelet function. This provides the information necessary to allow a personalized or individualized anti-platelet treatment regimen. Module 6, on PlateletMapping, covers this topic in greater detail.




Enzymatic hypercoagulability is characterized by rapid thrombin generation, leading to faster overall clot development. Causes include loss or reduction of endogenous antithrombotic mechanisms, such as acquired antithrombin III deficiency or activated protein C resistance, as demonstrated in patients with factor V Leiden defect.

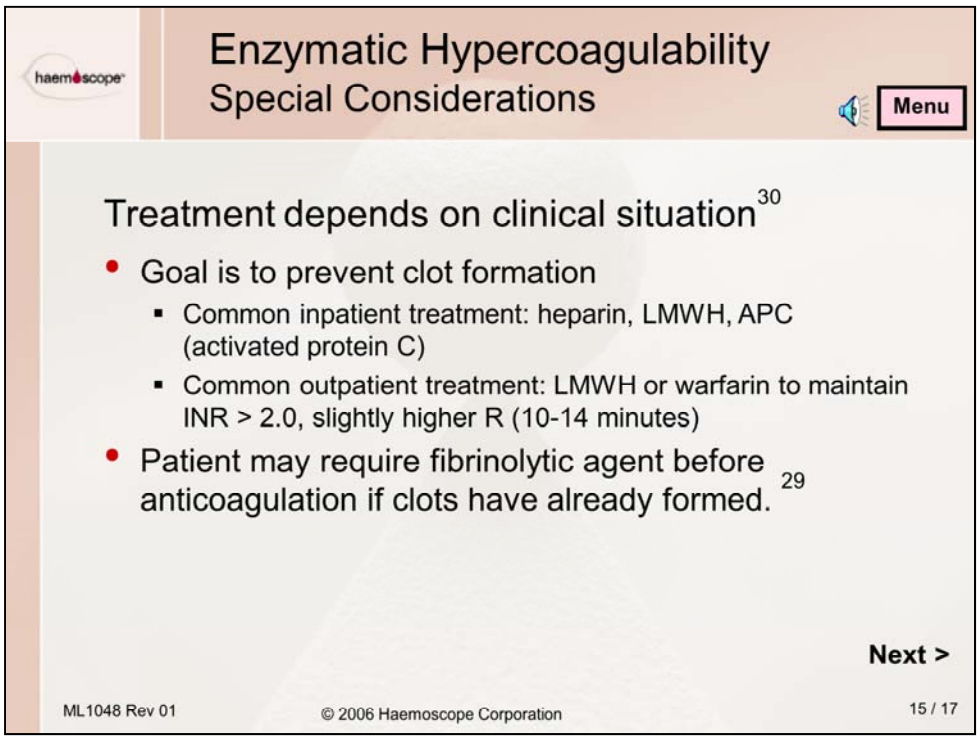
Dysfibrinogenemia is an inherited form of plasminogen deficiency that produces an abnormal, inactive form of plasminogen; it may also contribute to enzymatic hypercoagulability. Due to the role platelets play in the enzymatic pathway, enzymatic hypercoagulability is often associated with platelet hypercoagulability.




This tracing illustrates an isolated enzymatic hypercoagulable state, indicated by the low R and normal MA values. The probable cause of the low R value is rapid thrombin generation, which in turn increases the rate of fibrin formation and subsequent clot formation. The angle is also slightly above normal, indicating increased fibrin generation, a consequence of enzymatic hypercoagulability.

The patient is at risk of a thrombotic event associated with fibrin clot formation. Although overall clot strength is not excessive, formation of a fibrin clot can still result in thrombosis.

Since the hypercoagulability is isolated to the enzymatic pathway, the common treatment is an anticoagulant such as heparin, low molecular weight heparin, activated protein C, or a direct thrombin inhibitor.[30]

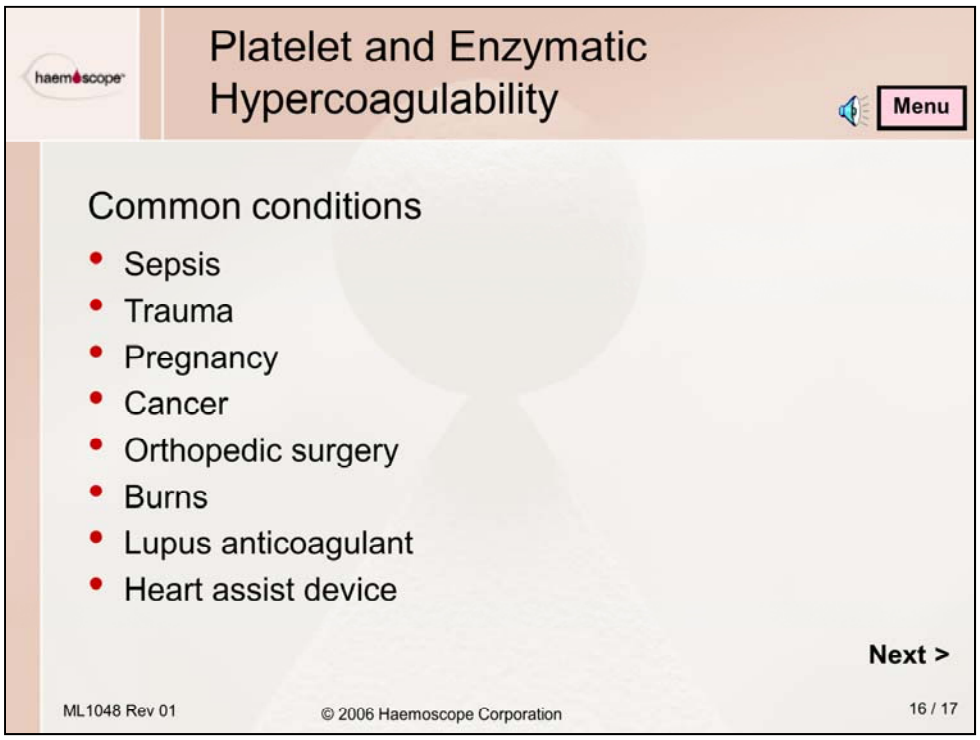



As with platelet hypercoagulability, there are special considerations in the treatment of enzymatic hypercoagulability, depending on the clinical status of the patient. The primary goal of the treatment is to prevent fibrin clot formation, and the common treatment is anticoagulation.[30]

For inpatients, common anticoagulants are heparin, low molecular weight heparin (LMWH), and possibly APC.

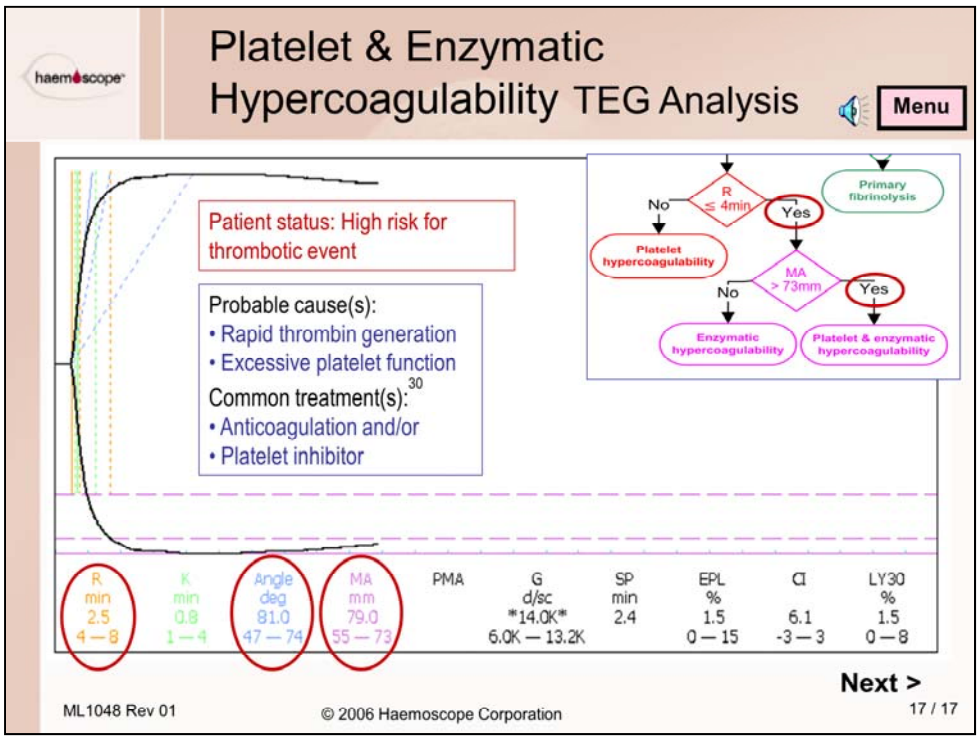
For outpatients, common anticoagulants include LMWH and warfarin (coumadin), in dosages such that patients can maintain an INR greater than 2.0 and a slightly higher than normal TEG R value, in the range of 10 - 14 minutes.

In cases where clots have already formed, a fibrinolytic agent is usually administered to break down the clots before anticoagulation is started.[29]




Due to the interaction of the platelet and enzymatic reaction, it is not uncommon to see hypercoagulability in both. Common conditions associated with platelet and enzymatic hypercoagulability include sepsis, trauma, and pregnancy, which naturally induces a prothrombotic condition. Also, amniotic fluid is rich in tissue factor.

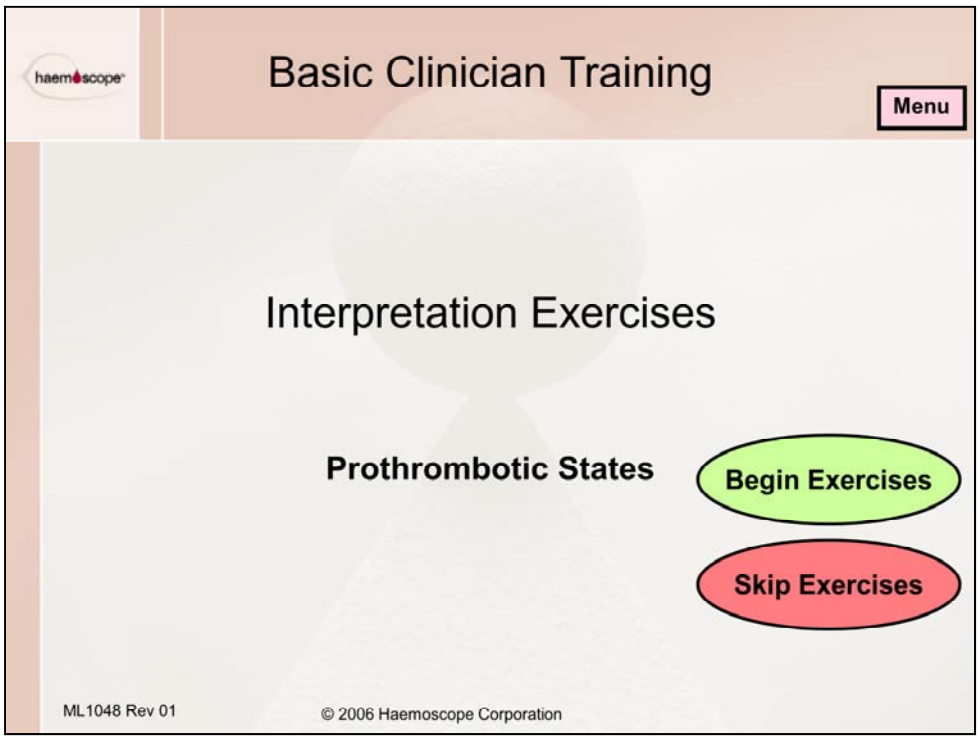
Other common conditions are certain types of cancer, orthopedic surgery, burns, the presence of the lupus anticoagulant, and support by a heart assist device.




This tracing demonstrates both platelet and enzymatic hypercoagulability, indicated by a high MA and a low R value. Since both components are hyperactive, the rate of fibrin formation is also accelerated, leading to a high angle value. This patient is potentially at high risk for a thrombotic event.

As indicated by the tracing, probable causes of hypercoagulability are rapid thrombin generation, with subsequent fibrin formation, and excessive platelet function.

Since both the enzymatic and platelet pathways are involved, common treatment includes the combination of an anticoagulant and an antiplatelet agent.[30]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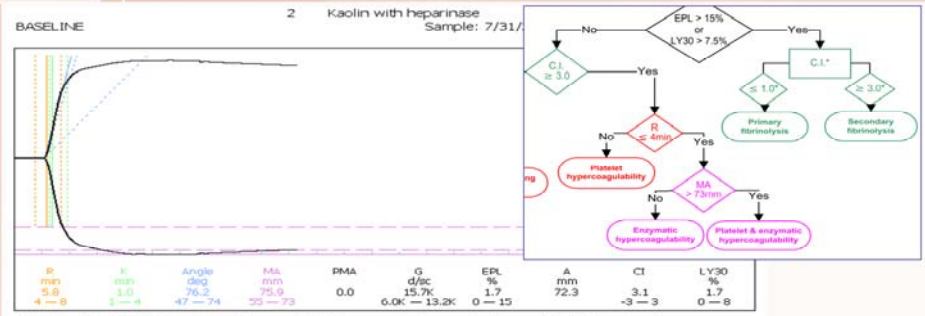
# Exercise 1




**Using the TEG decision tree, what is your interpretation of this tracing?**
**(Select all that apply)**

a) Platelet hypercoagulability
b) Enzymatic hypercoagulability
c) Platelet and enzymatic hypercoagulability
d) Secondary fibrinolysis

**What would be an appropriate treatment for this patient?**

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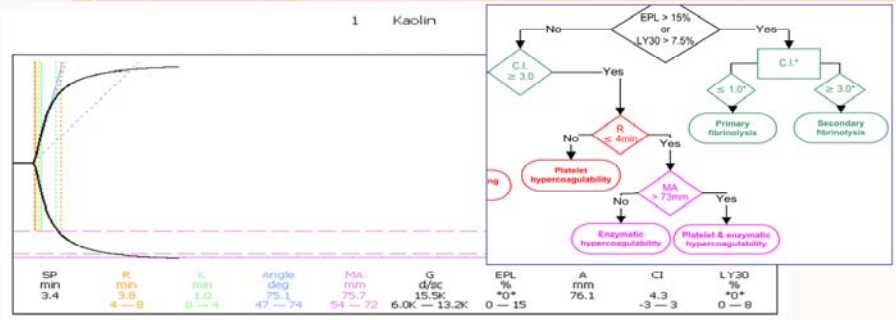
# Exercise 2




**Using the TEG decision tree, what is your interpretation of this tracing?**
**(Select all that apply)**

a) Platelet hypercoagulability
b) Enzymatic hypercoagulability
c) Platelet and enzymatic hypercoagulability
d) Secondary fibrinolysis

**What would be an appropriate treatment for this patient?**

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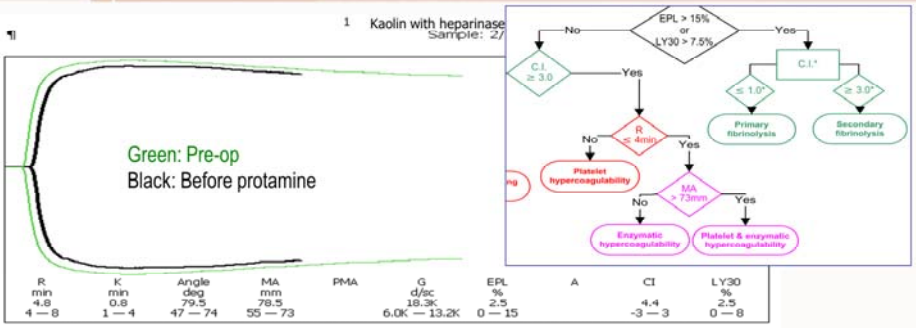
# Exercise 3




**These tracings are from a patient who has undergone an off-pump CABG. What is this patient's current hemostatic state (black tracing)?**

a) Platelet hypercoagulability
b) Enzymatic hypercoagulability
c) Platelet and enzymatic hypercoagulability
d) Secondary fibrinolysis

**What would be an appropriate treatment for this patient?**

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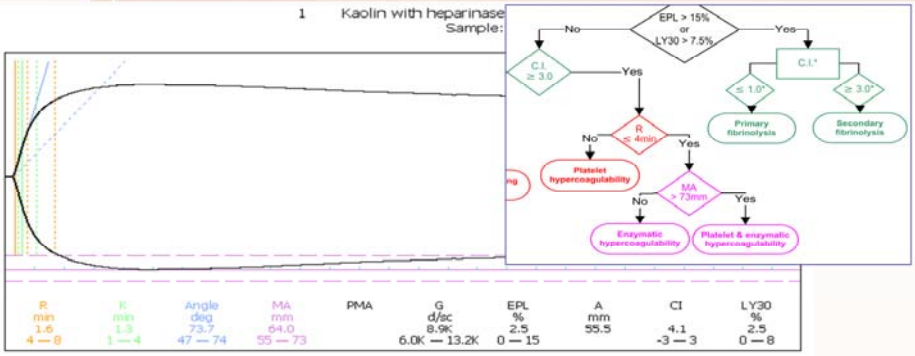
# Exercise 4




**Using the TEG decision tree, what is your interpretation of this tracing?**
**(Select all that apply)**

a) Platelet hypercoagulability
b) Enzymatic hypercoagulability
c) Platelet and enzymatic hypercoagulability
d) Secondary fibrinolysis

**What would be an appropriate treatment for this patient?**

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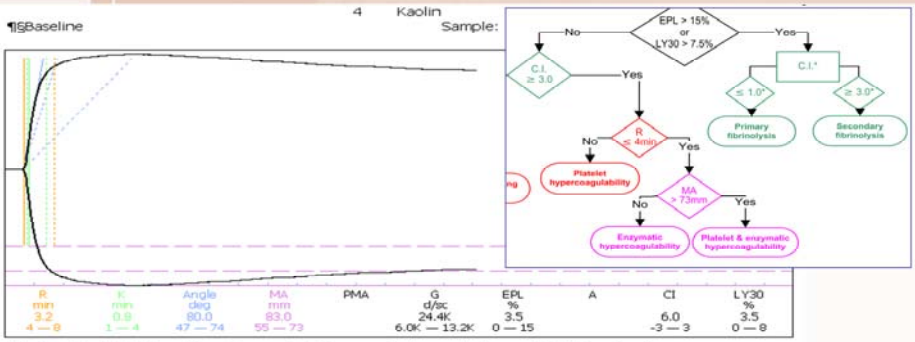
# Exercise 5




**Using the TEG decision tree, what is your interpretation of this tracing?**
**(Select all that apply)**

a) Platelet hypercoagulability
b) Enzymatic hypercoagulability
c) Platelet and enzymatic hypercoagulability
d) Secondary fibrinolysis

**What would be an appropriate treatment for this patient?**

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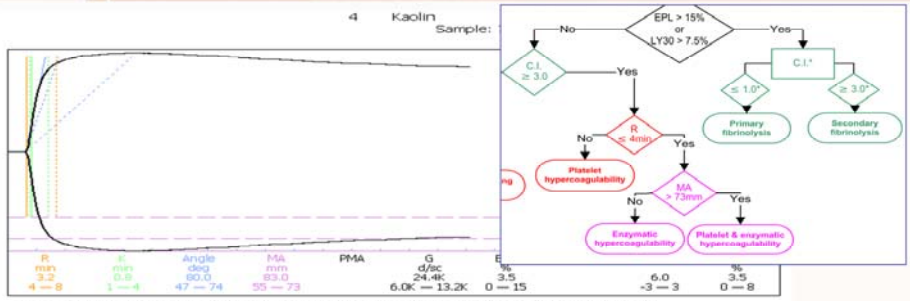
# Exercise 6




**Using the TEG decision tree, what is your interpretation of this tracing? (select all that apply)**

a) Platelet hypercoagulability
b) Enzymatic hypercoagulability
c) Platelet and enzymatic hypercoagulability
d) Secondary fibrinolysis

**If this tracing were from a pre-bypass cardiac surgical patient, what type of antifibrinolytic treatment would you consider?**

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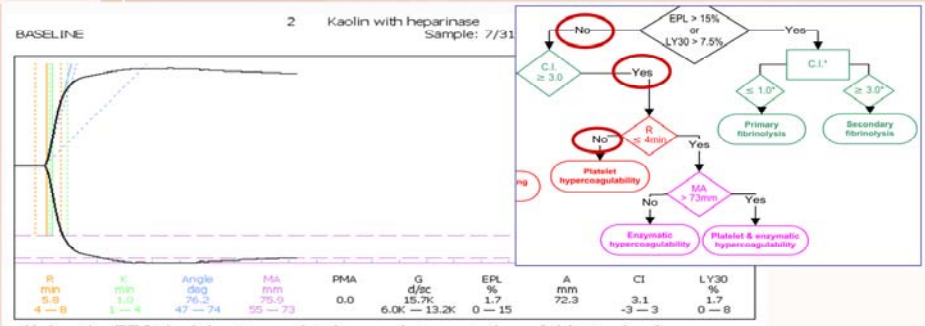
# Answer to Exercise 1




**Using the TEG decision tree, what is your interpretation of this tracing? (select all that apply)**

**a) Platelet hypercoagulability**

b) Enzymatic hypercoagulability

c) Platelet and enzymatic hypercoagulability

d) Secondary fibrinolysis

**What would be an appropriate treatment for this patient?**

Consider an anti-platelet agent.[30]

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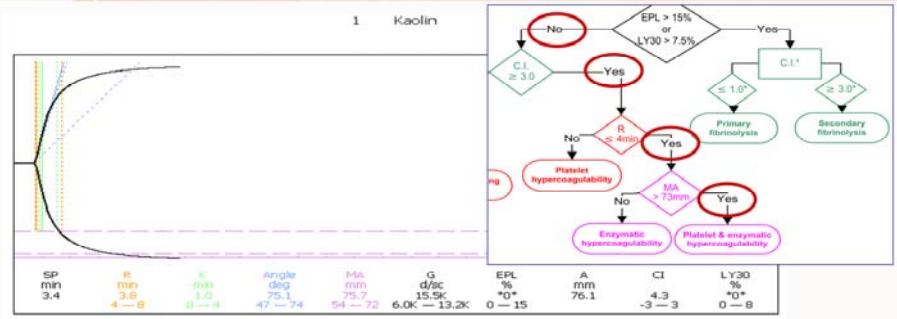
# Answer to Exercise 2




**Using the TEG decision tree, what is your interpretation of this tracing? (select all that apply)**

a) Platelet hypercoagulability
b) Enzymatic hypercoagulability
**c) Platelet and enzymatic hypercoagulability**
d) Secondary fibrinolysis

**What would be an appropriate treatment for this patient?**

Consider treatment with both an anticoagulant and an anti-platelet agent.

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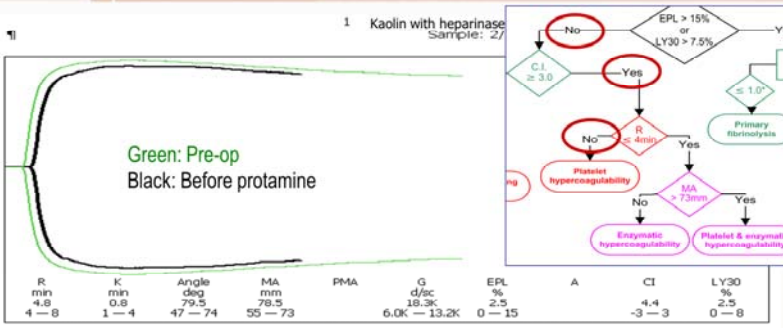
# Answer to Exercise 3







**These tracings are from a patient who has undergone an off-pump CABG. What is this patient's current hemostatic state (black tracing)?**

**a) Platelet hypercoagulability**

b) Enzymatic hypercoagulability

c) Platelet and enzymatic hypercoagulability

d) Secondary fibrinolysis

**What would be an appropriate treatment for this patient?**

Although the R value is within normal range, the pre-op value was lower than normal. Consider half the normal protamine dose, plus an anti-platelet agent.

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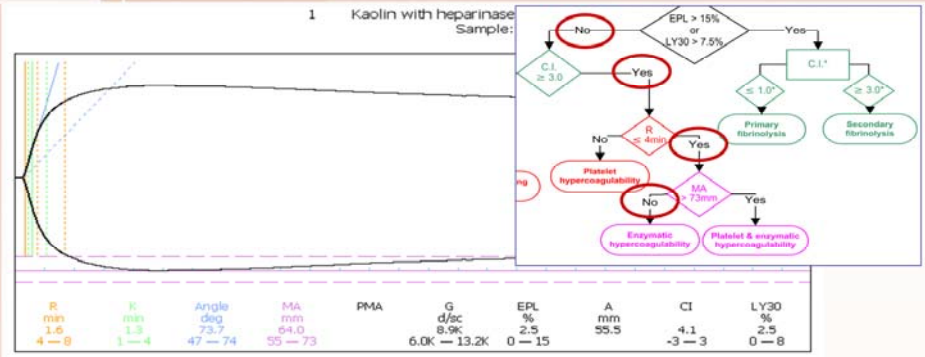
# Answer to Exercise 4




**Using the TEG decision tree, what is your interpretation of this tracing? (select all that apply)**

a) Platelet hypercoagulability

**b) Enzymatic hypercoagulability**

c) Platelet and enzymatic hypercoagulability

d) Secondary fibrinolysis

**What would be an appropriate treatment for this patient?**

Consider treatment with an anticoagulant.[30]

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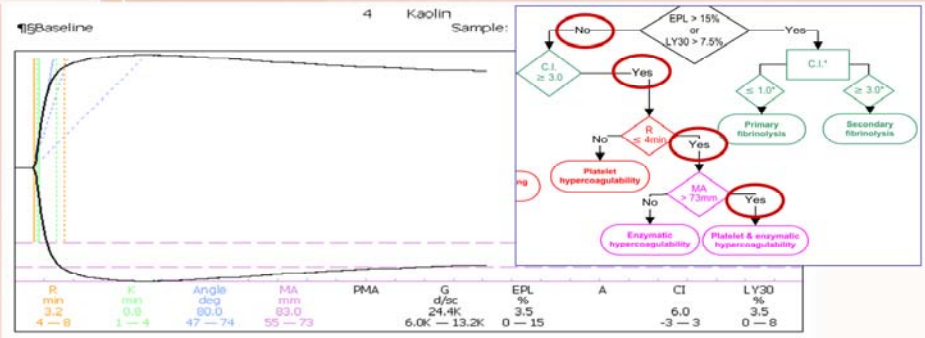
# Answer to Exercise 5




**Using the TEG decision tree, what is your interpretation of this tracing? (select all that apply)**

a) Platelet hypercoagulability
b) Enzymatic hypercoagulability
**c) Platelet and enzymatic hypercoagulability**
d) Secondary fibrinolysis

**What would be an appropriate treatment for this patient?**

Consider treatment with both an anticoagulant and an anti-platelet agent.[30]

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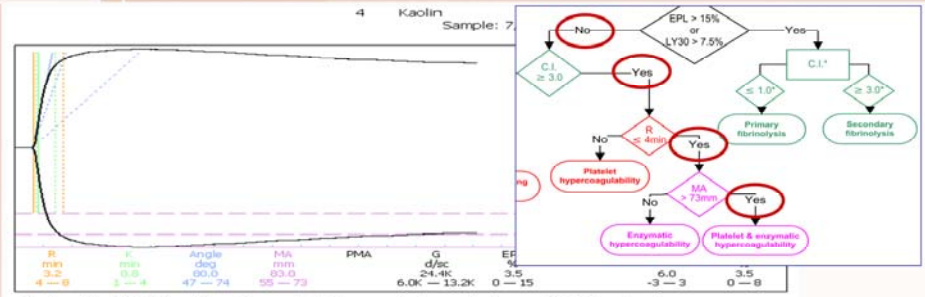
# Answer to Exercise 6




**Using the TEG decision tree, what is your interpretation of this tracing? (select all that apply)**

a) Platelet hypercoagulability
b) Enzymatic hypercoagulability
**c) Platelet and enzymatic hypercoagulability**
d) Secondary fibrinolysis

**If this tracing were from a pre-bypass cardiac surgical patient, what type of antifibrinolytic treatment would you consider?**

None. Since the patient is hypercoagulable, treatment with an antifibrinolytic agent may be contra-indicated. Repeat a TEG analysis during CPB to determine if fibrinolysis has developed, and treat accordingly.[30]

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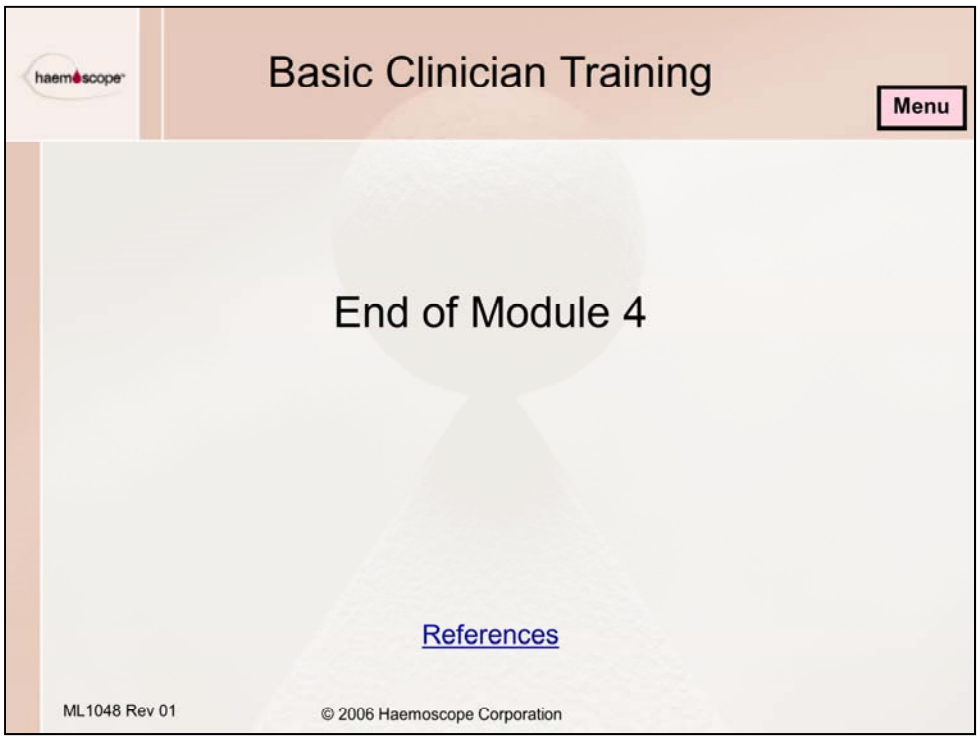
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