Thromboelastograph :
An Introduction

Andy N.D. Nguyen, M.D.

Thromboelastograph (TEG): principles

Measuring the mechanical properties of the developing clot:

- The time it takes until initial fibrin formation.

- The kinetics of the initial fibrin clot to reach maximum strength.

- The ultimate strength and stability of the fibrin clot, ie. its ability to mechanically impede hemorrhage without permitting inappropriate thrombosis.

- Since the TEG analyzer monitors the shear elasticity of clotting blood, it is sensitive to all the interacting cellular and plasma components such as coagulation and fibrinolytic factors, activators, and inhibitors, that may effect the rate or structure of a clotting sample and its breakdown.

A commonly-used TEG Analyzer

- This presentation will be based on a widely-used TEG analyzer: TEG-5000 Thrombelastograph® Hemostasis Analyzer (Haemoscope Co., Niles, IL)
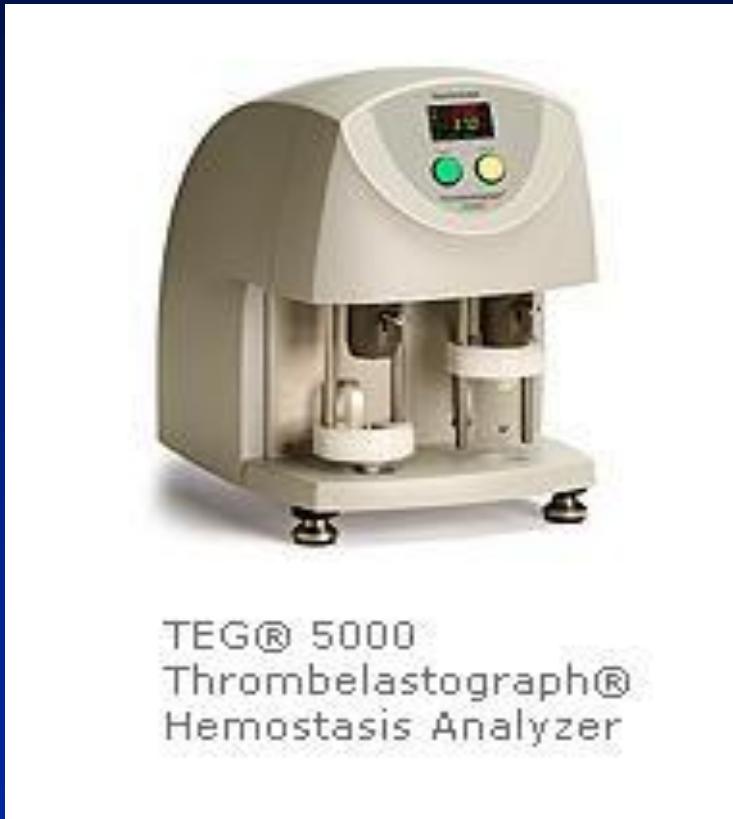
TEG® 5000
Thrombelastograph®
Hemostasis Analyzer

- The TEG analyzer has a sample cup that oscillates back and forth constantly at a set speed through an arc of 4°45'. Each rotation lasts ten seconds. A whole blood sample of 360 ul is placed into the cup, and a stationary pin attached to a torsion wire is immersed into the blood.

- When the first fibrin forms, it begins to bind the cup and pin, causing the pin to oscillate in phase with the clot. The acceleration of the movement of the pin is a function of the kinetics of clot development.

Torsion wire

Pin

Cup

.36 ml whole blood
(Clotted)

Heating element,
sensor & controller

4°45
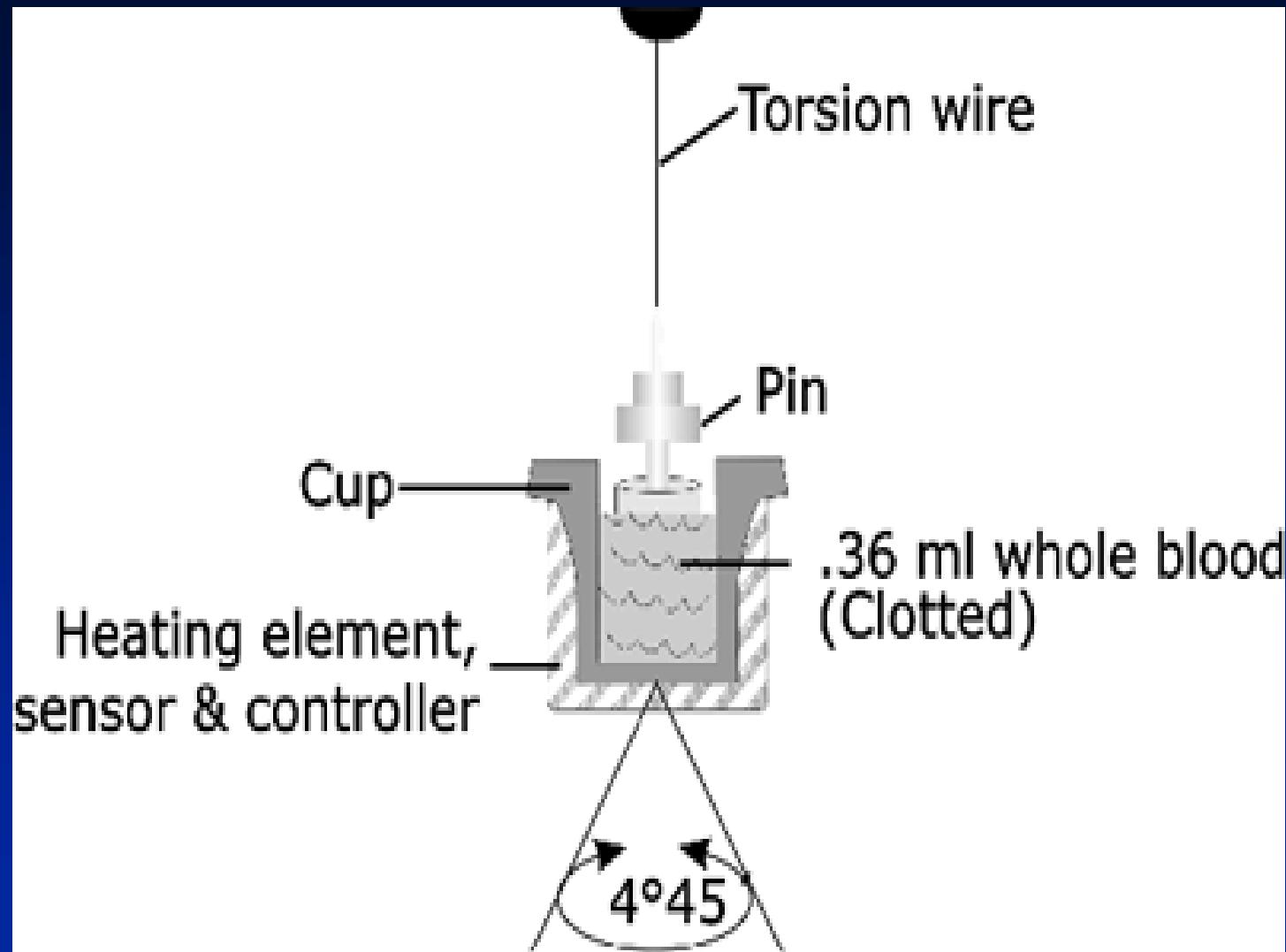
- The torque of the rotating cup is transmitted to the immersed pin only after fibrin-platelet bonding has linked the cup and pin together. The strength of these fibrin-platelet bonds moves the pin directly in phase with the cup motion. Thus, the magnitude of the output is directly related to the strength of the formed clot.

- As the clot retracts or lyses, these bonds are broken and the transfer of cup motion is diminished. The rotation movement of the pin is converted by a mechanical-electrical transducer to an electrical signal which can be monitored by a computer.

- The resulting hemostasis profile is a measure of:

  -The time it takes for the first fibrin strand to be formed,
  -The kinetics of clot formation,
  -The strength of the clot (in shear elasticity units of dyn/cm2), and
  -Dissolution of clot.

- Whole blood samples provide the most sensitive method for analysis. However, most times it is not practical or necessary to run a straight native sample. Samples can be citrated to prolong storage time. Calcium Chloride is added to the sample at testing time

- Testing sample may be native blood, or with added reagents. Added reagents may include: kaolin, Aprotinin, heparinase. Appropriate reference ranges are used for each type

Parameters of clot dynamics
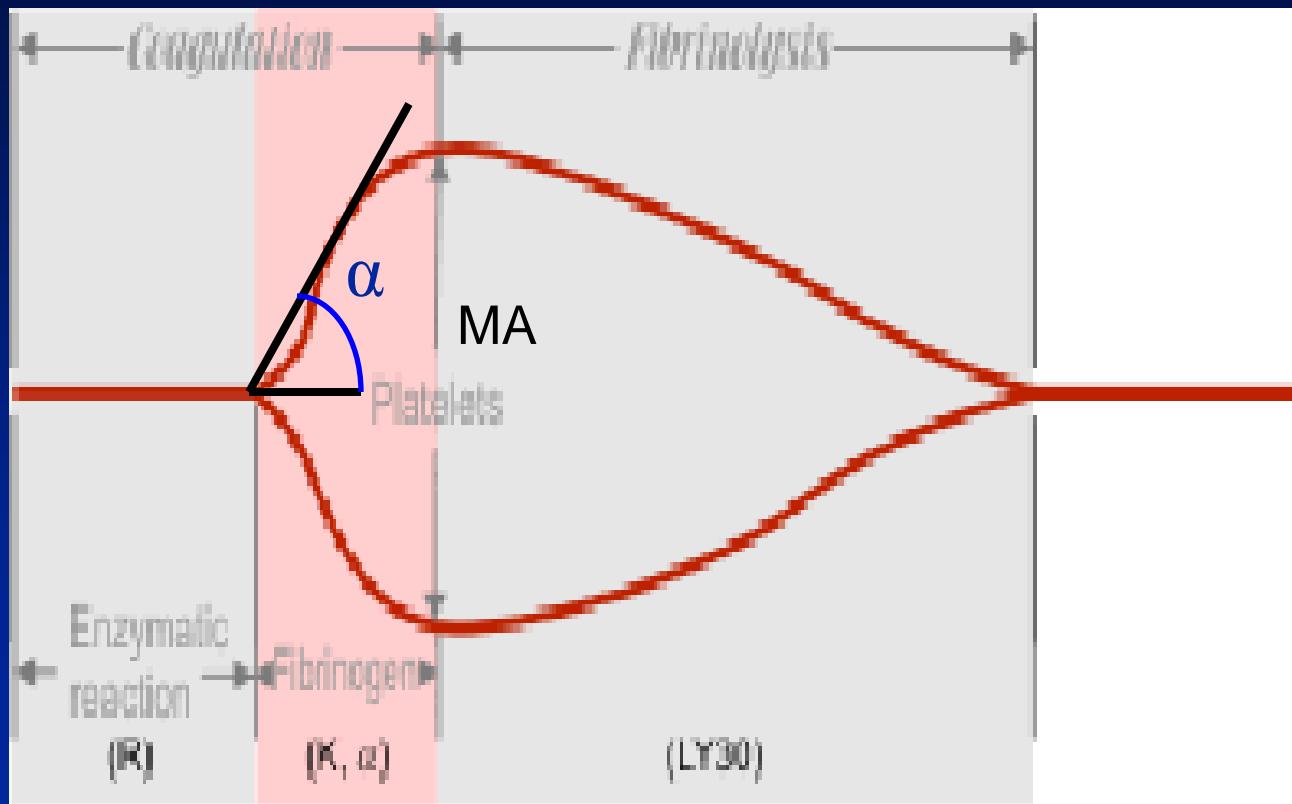
Parameters of clot dynamics

Clotting time	ℝ	The period of time of latency from the time that the blood was placed in the TEG analyzer until the initial fibrin formation (MA= 2 mm).
Clot kinetics	K	A measure of the speed to reach a specific level of clot strength (MA= 20 mm).
	alpha	Measures the rapidity of fibrin build-up and cross-linking (clot strengthening)
Clot strength	MA,G	A direct function of the maximum dynamic properties of fibrin and platelet bonding via GPIIb/IIIa and represents the ultimate strength of the fibrin clot.
Hemostasis profile	CI	Coagulation Index, which is a linear combination of the above parameters.
Clot stability	LY30	Measures the rate of amplitude reduction 30 minutes after MA.

Interpretation of TEG tracings

- TEG is a global test for hemostasis that includes interaction of primary and secondary hemostasis

- Subsequently, defect in one component of hemostasis can affect the other to certain extense

- In reading TEG data/tracing, it is most important to focus on the most significant defect

Patterns of TEG Tracings

- **Normal**
  R;K;MA;Angle = Normal

- **Anticoagulants/hemophilia**
  Factor Deficiency
  R;K = Prolonged
  MA;Angle = Decreased

- **Platelet Blockers**
  Thrombocytopenia/Thrombocytopathy
  R ~ Normal; K = Prolonged
  MA = Decreased

- **Fibrinolysis**
  R ~ Normal;
  MA = Continuous Decrease
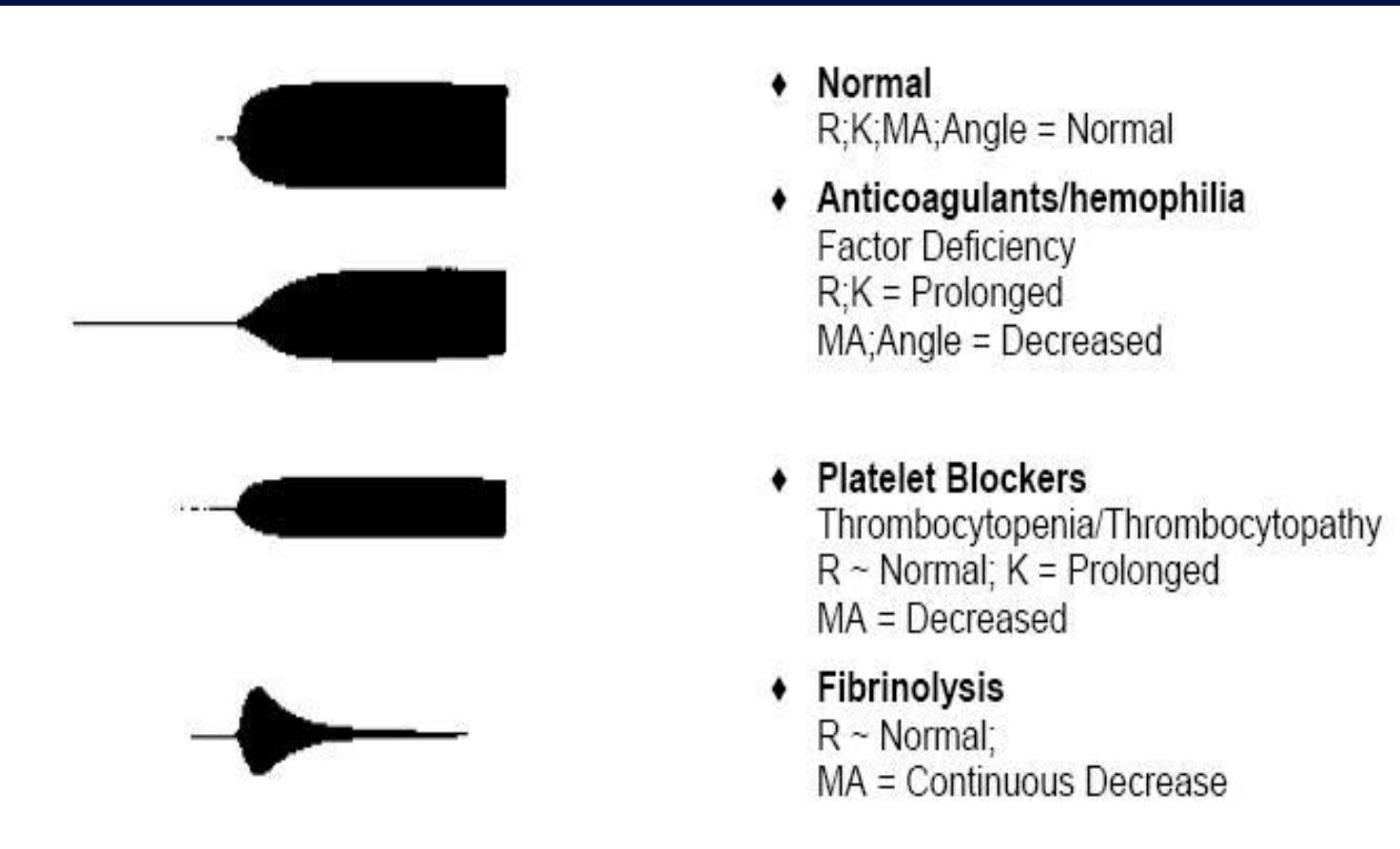
Patterns of TEG Tracings

♦ **Hypercoagulation**
R;K = Decreased
MA;Angle = Increased

♦ **D.I.C.**
Stage 1- Hypercoagulable state with
secondary fibrinolysis

♦ Stage 2 - Hypocoagulable state

Diagnostic algorithm
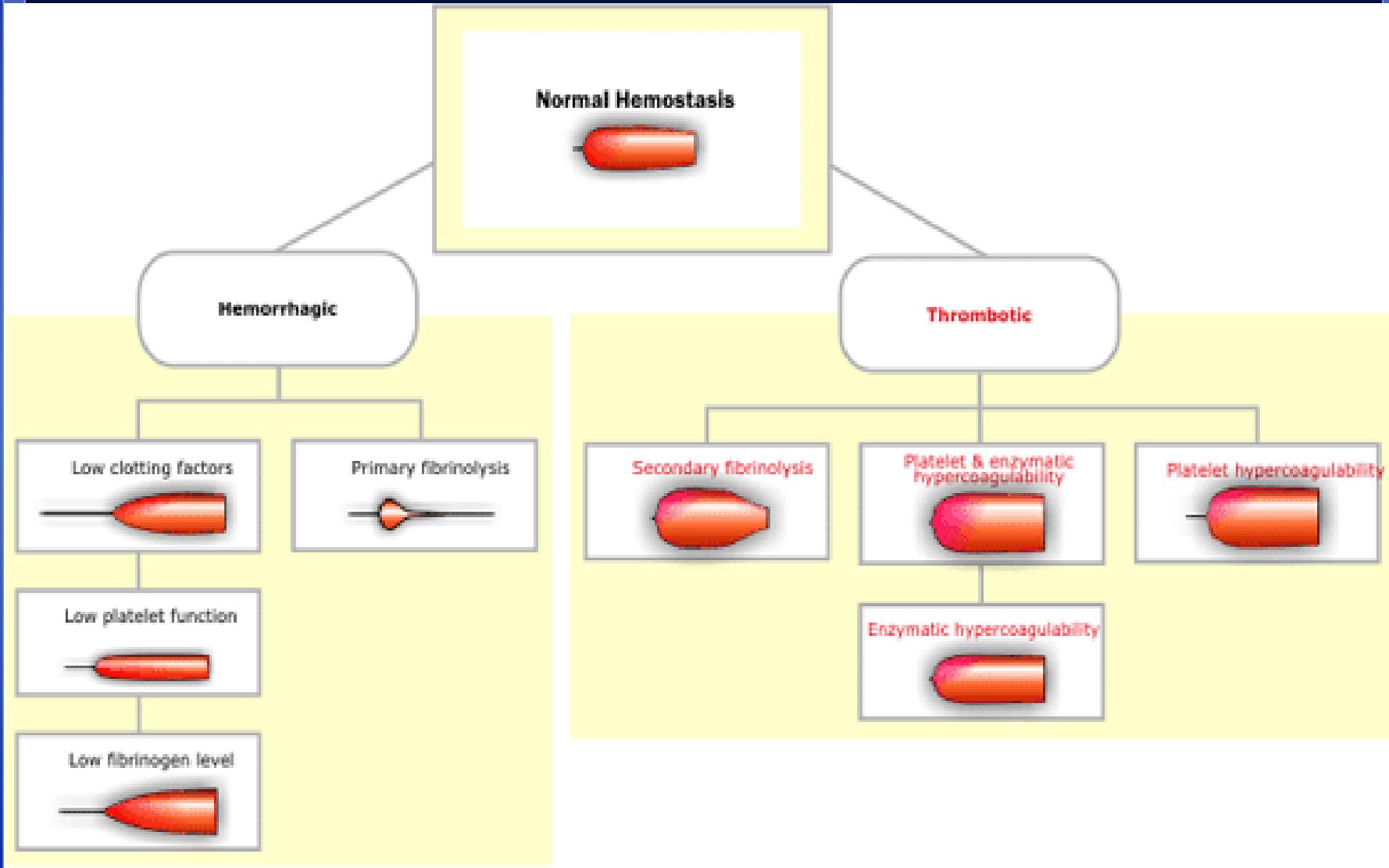
Normal hemostasis: Normal R, α, MA, LY30
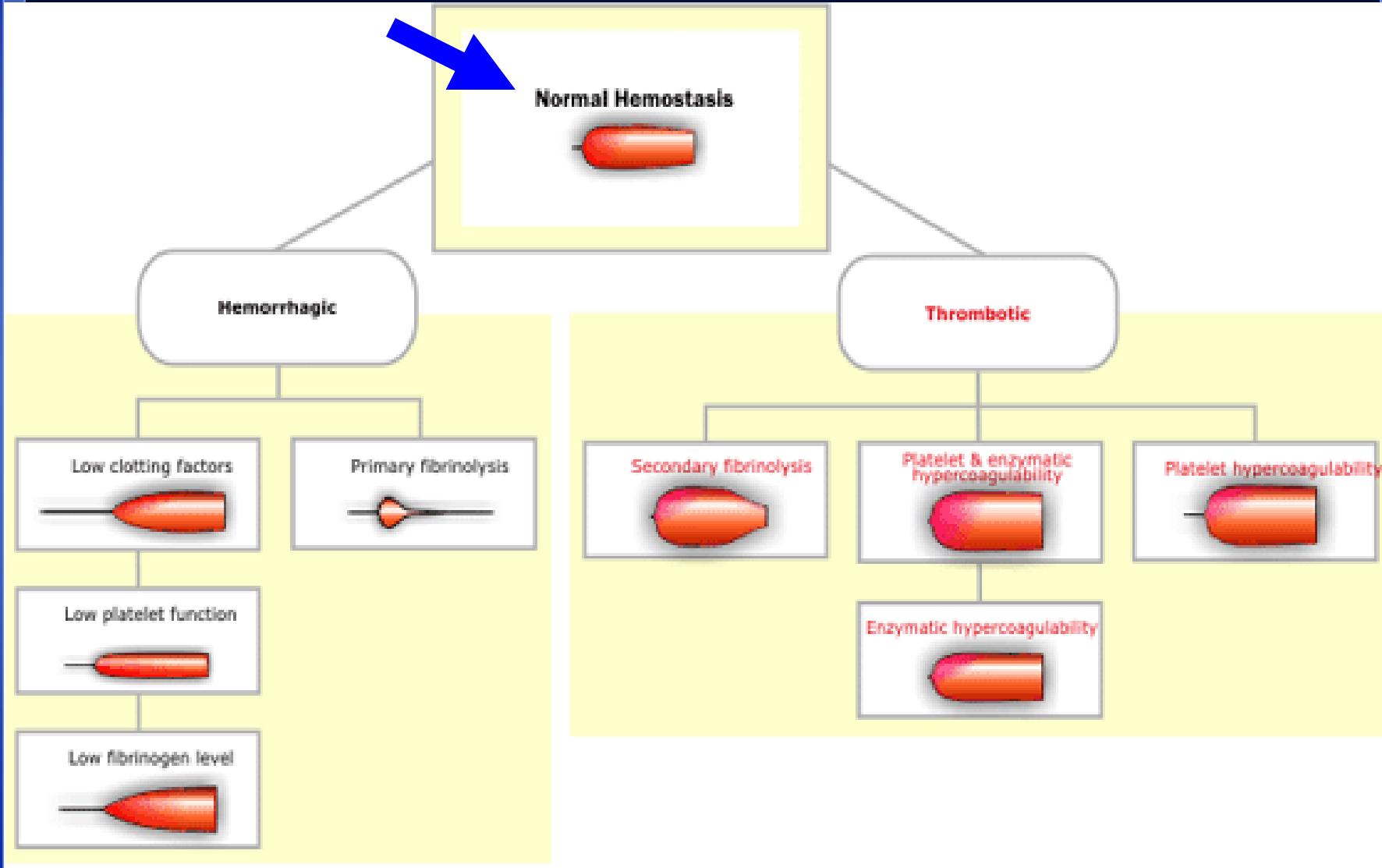
Low clotting factors: high R, low α, nl/low MA, nl LY30
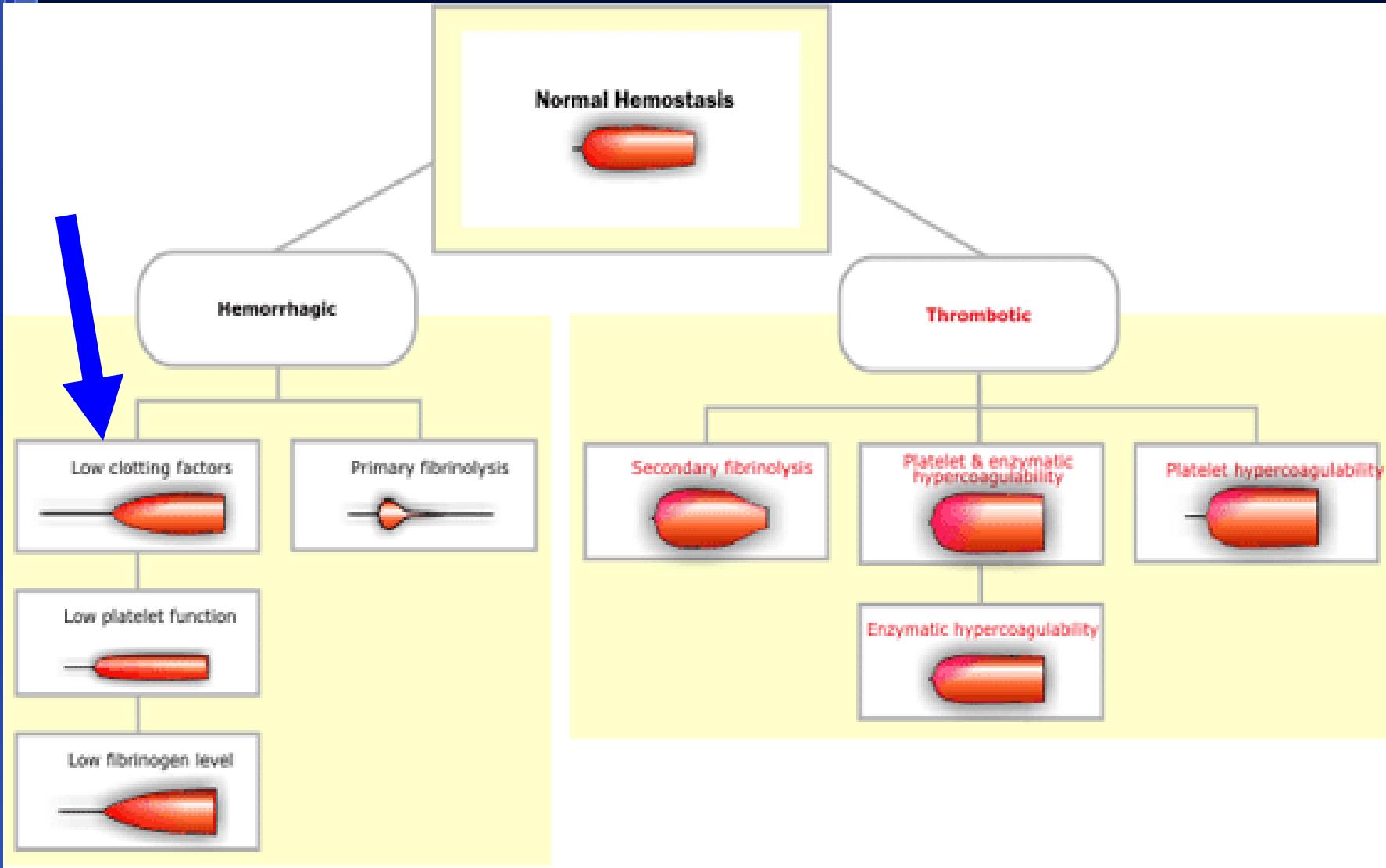
Low platelets (number/function): nl/high R, low α, low MA, nl LY30
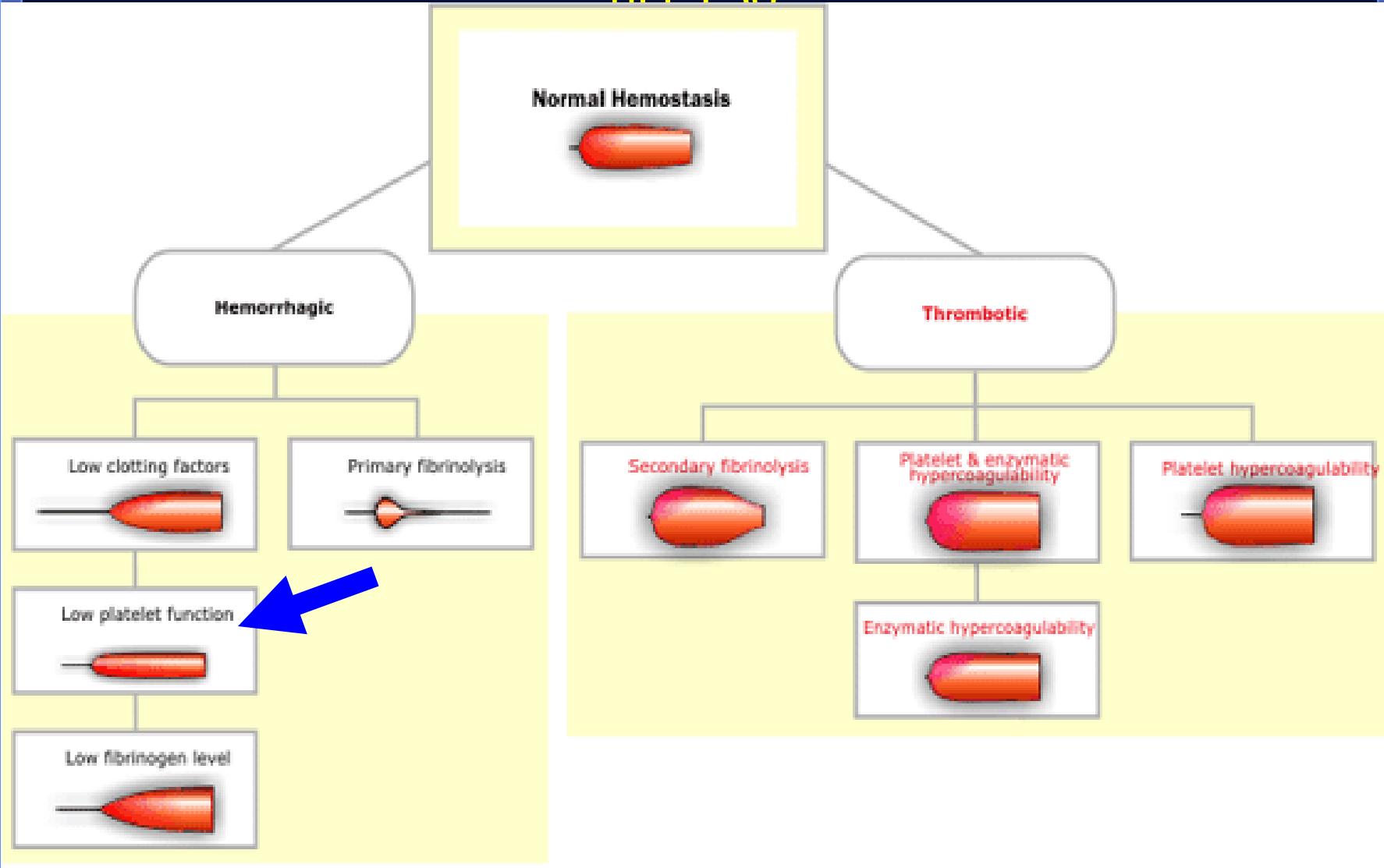
Low fibrinogen: high R, low α, nl/low MA, nl LY30
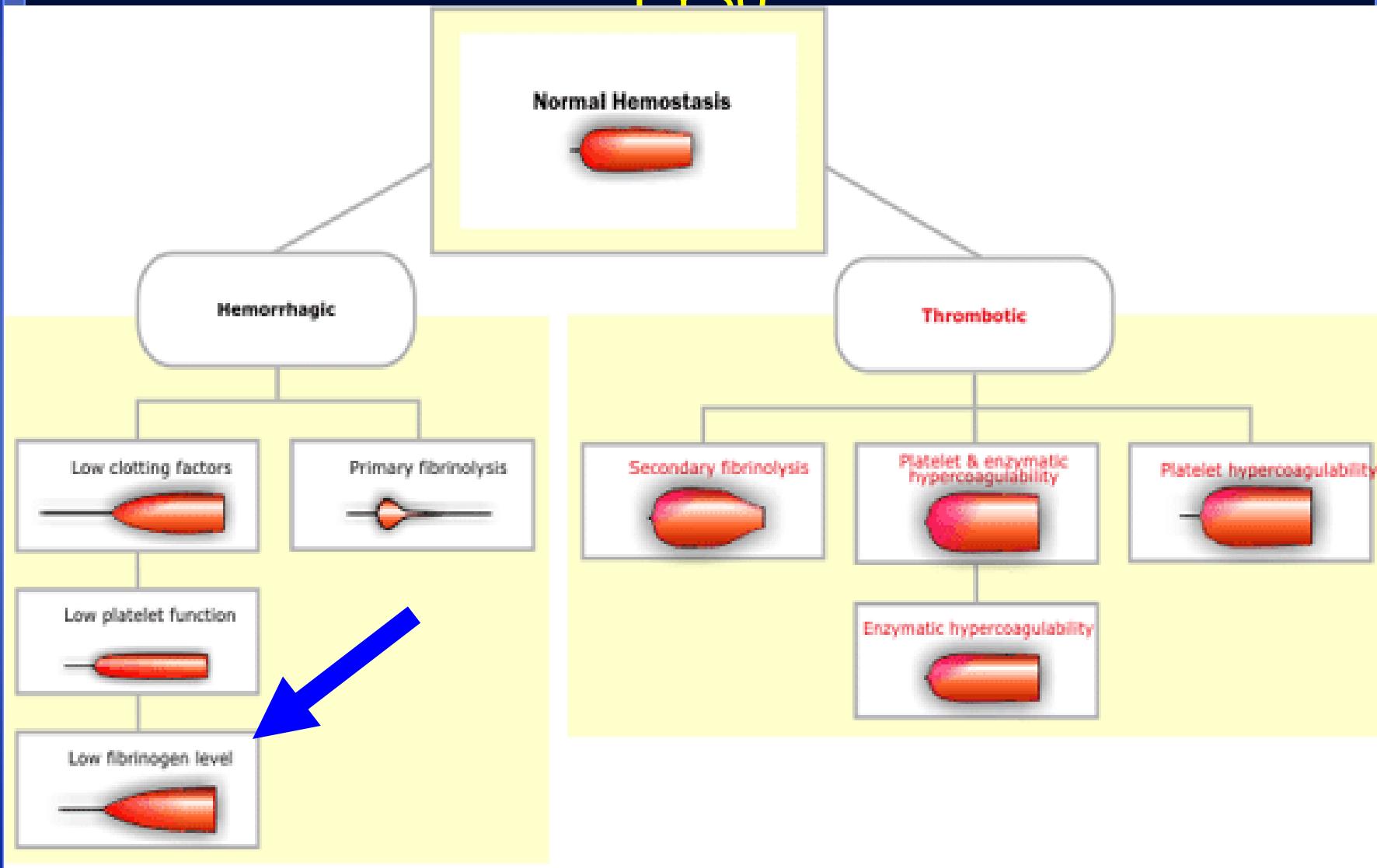
Primary fibrinolysis: high R, nl/low α, low MA, high LY30
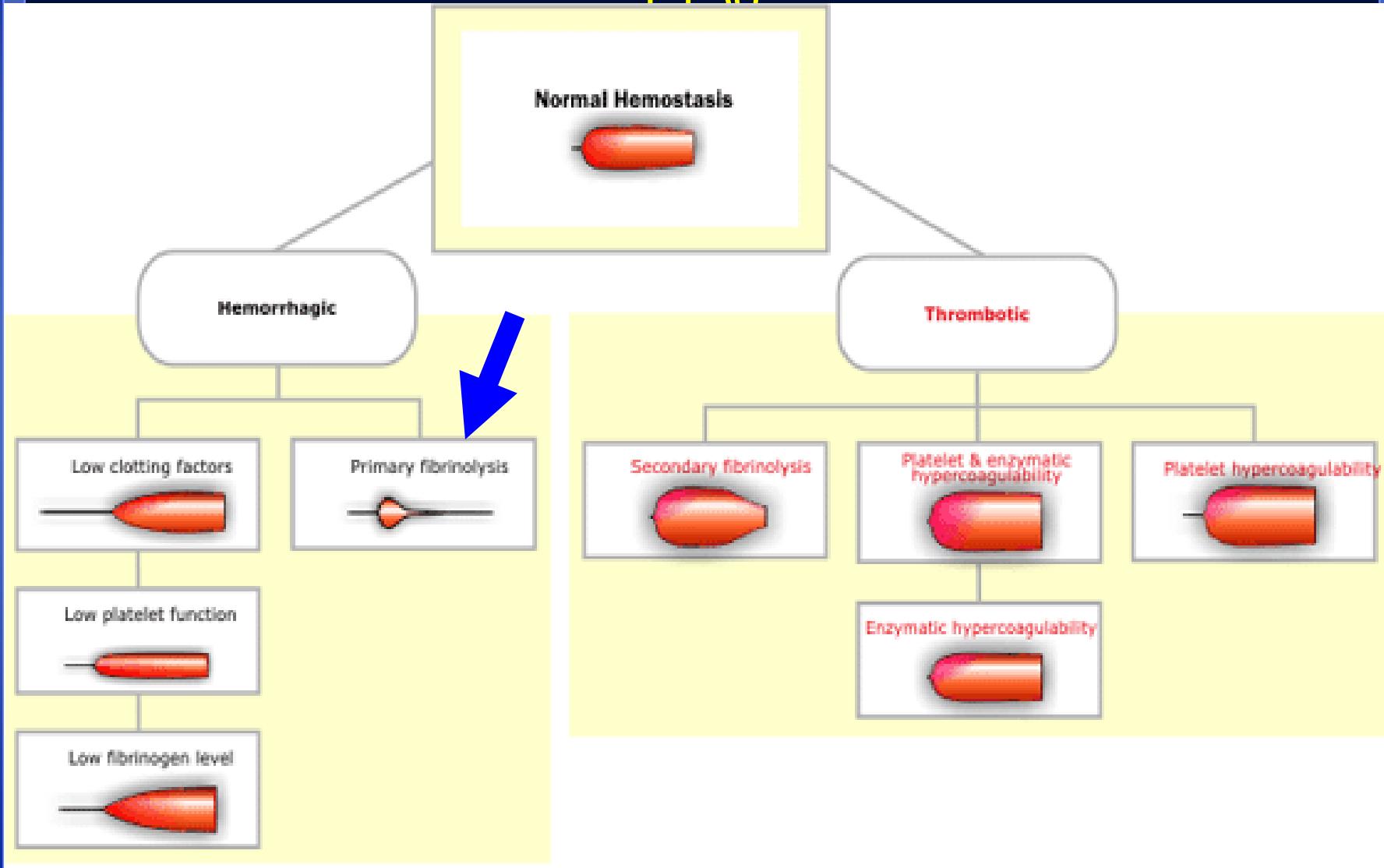
Platelet hypercoagulation: nl R, nl α, high MA, nl LY30
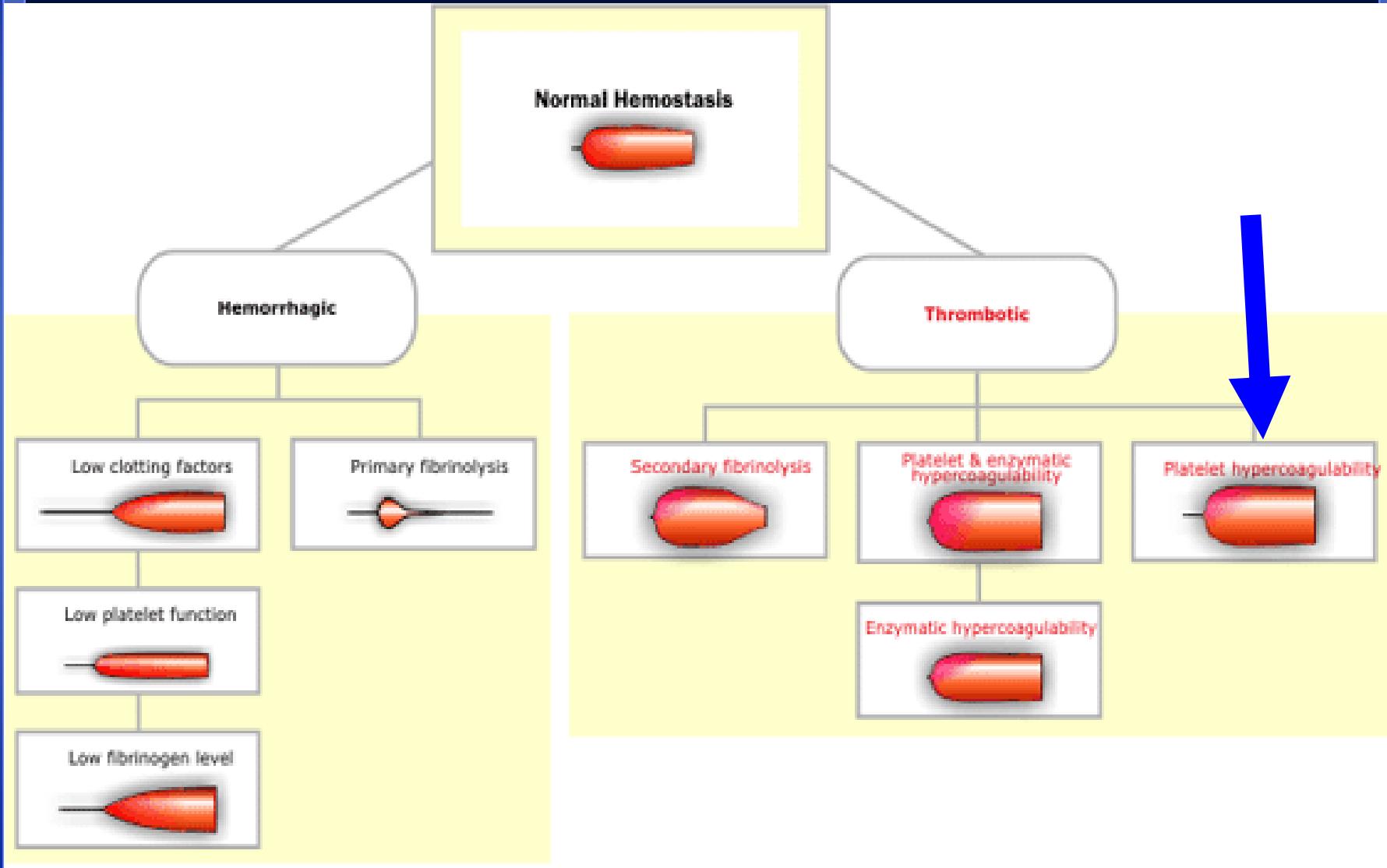
Enzymatic hypercoagulation: low R, high α, nl MA, nl LY30
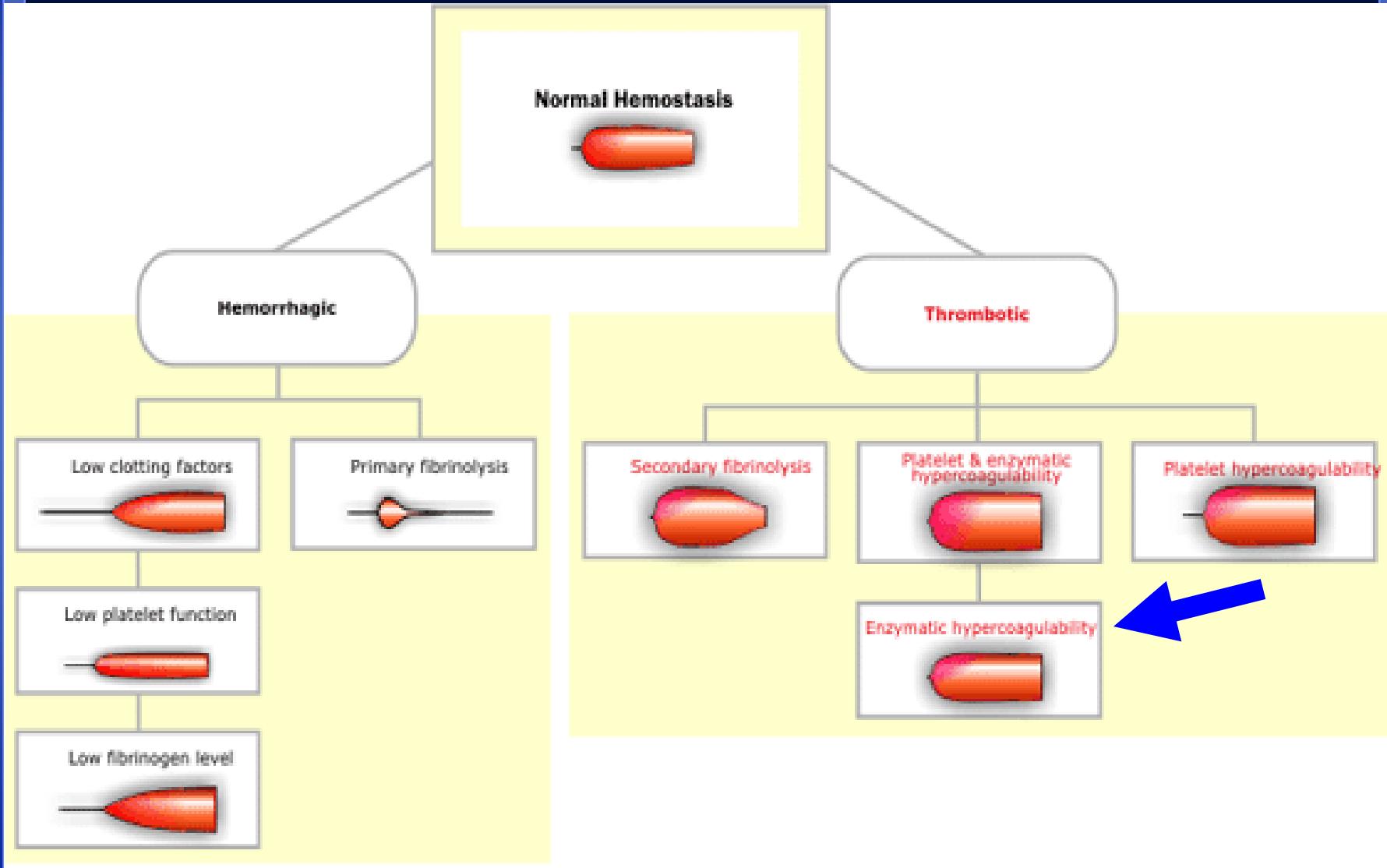
Platelet/enzymatic hypercoagulation: low R, high α, high MA, nl LY30
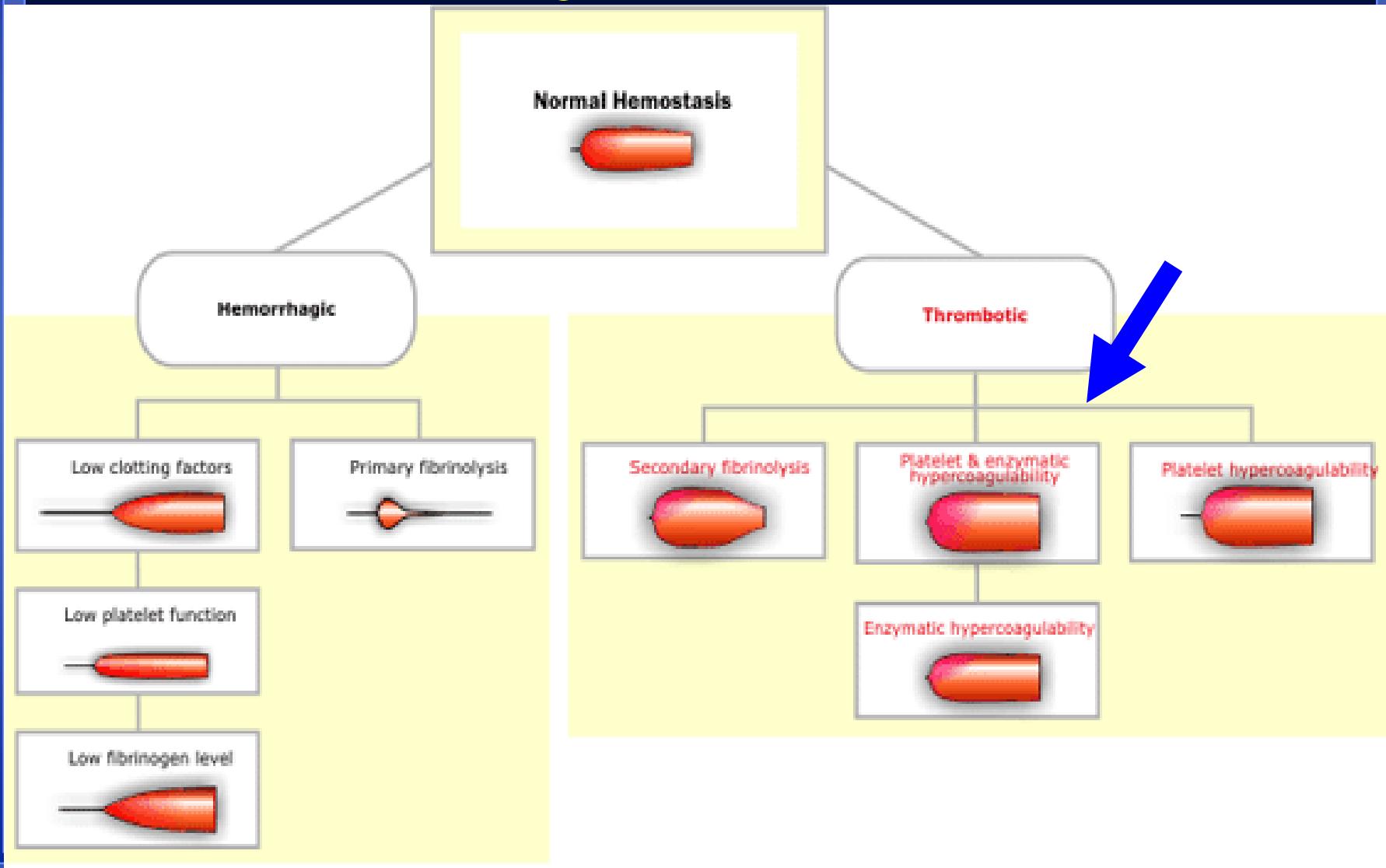
Secondary fibrino;ysis (DIC, stage 1): low R, high α, high MA, high LY30
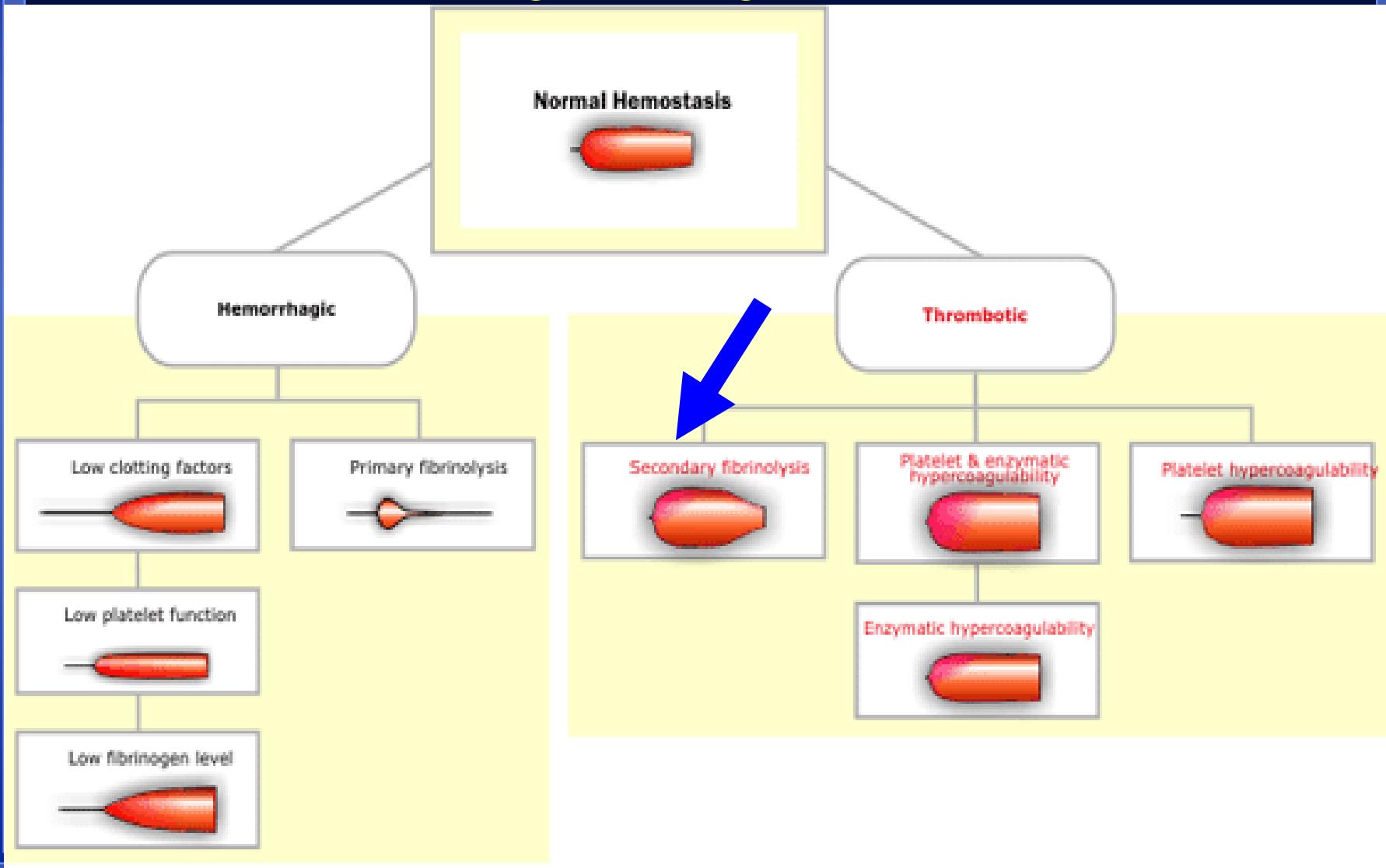
TEG: Ref ranges

- R-time: 3.0-8.0 min
- K-time: 1.0-4.0   min
- Angle: 55.0-78.0 degree
- Max Amp: 51.0-69.0 mm
- G-value: 4.6-10.9 10^3 d/sc
- Ly30: 0.0-7.5 %
- Coag Index: -3.0 to +3.0

Normal ranges are for citrated whole blood with kaolin activator.

	R	Alpha	MA	LY30		
Normal	N	N	N	N		
Factor deficiency/ hypofibrinogenemia/ heparin/coumadin	++	N/-	N/-	N		
Thrombocytopenia/ platelet dysfunction	N/+	N/-	--	N		
Primary fibrinolysis (tPA, UK, SK)	N/+	N/-	N/-	++		
Plt hypercoag (TTP, HIT)	N	N	++	N		
Enzymatic hypercoag (FV Leiden, LA, etc.)	--	N/+	N	N		
Plt/enzym hypercoag (early DIC)	--	N/+	++	N		
DIC with secondary fibrinolysis (stage 1)	--	N/+	++	++		
DIC with hypocoagulable state (stage 2)	++	N/-	--	N		

Legends:

- N: in ref range
- N/+: in or slightly above ref range
- N/-:   in or slightly below ref range
- ++:   marked increase above ref range
- --:   marked decrease below ref range

Rapid TEG

- Abbreviated TEG for rapid turn-around-time (trauma setting)
- Whole blood obtained in syrynge without anticoagulant, to be tested within 4 minutes after drawing
- No measurement of LY30
- Addition of activated clotting time (ACT) to better assess clotting factors (R is very short and less accurate)

Rapid TEG

- **ACT: 76-110 sec**
- **R-time: 0.3-0.6 min**
- **K-time: 0.5-2.0   min**
- **Angle: 66.3-81.9 degree**
- **Max Amp: 54.1-72.5 mm**
- **G-value: 5.3-12.4 10^3 d/sc**

Normal ranges are for non-anticoagulated whole blood