

# Trauma-induced Coagulopathy: Therapeutic Strategies

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Orthopaedic Trauma Course

# Disclosures

- **Scientific Advisory Committee**
  - Osteoporosis Canada
- **Institutional Research Funding**
  - Smith & Nephew
  - Johnson & Johnson
- **Educational Engagements**
  - Stryker
- **Associate Editor**
  - Canadian Journal of Surgery



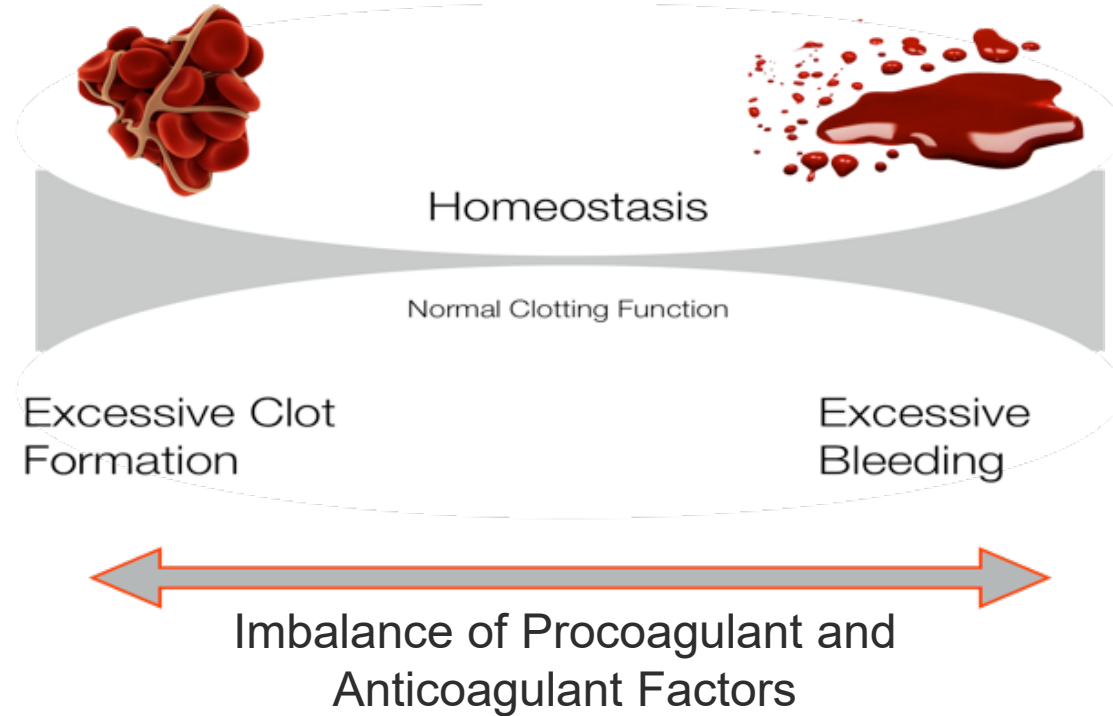
# Outline

- Define trauma-induced coagulopathy
- Overview of viscoelastic testing (TEG) in trauma
- Therapeutic strategies for hemorrhage
- Burden of venous thromboembolism
- Therapeutic strategies for thromboprophylaxis
- Future directions



# Trauma-induced Coagulopathy

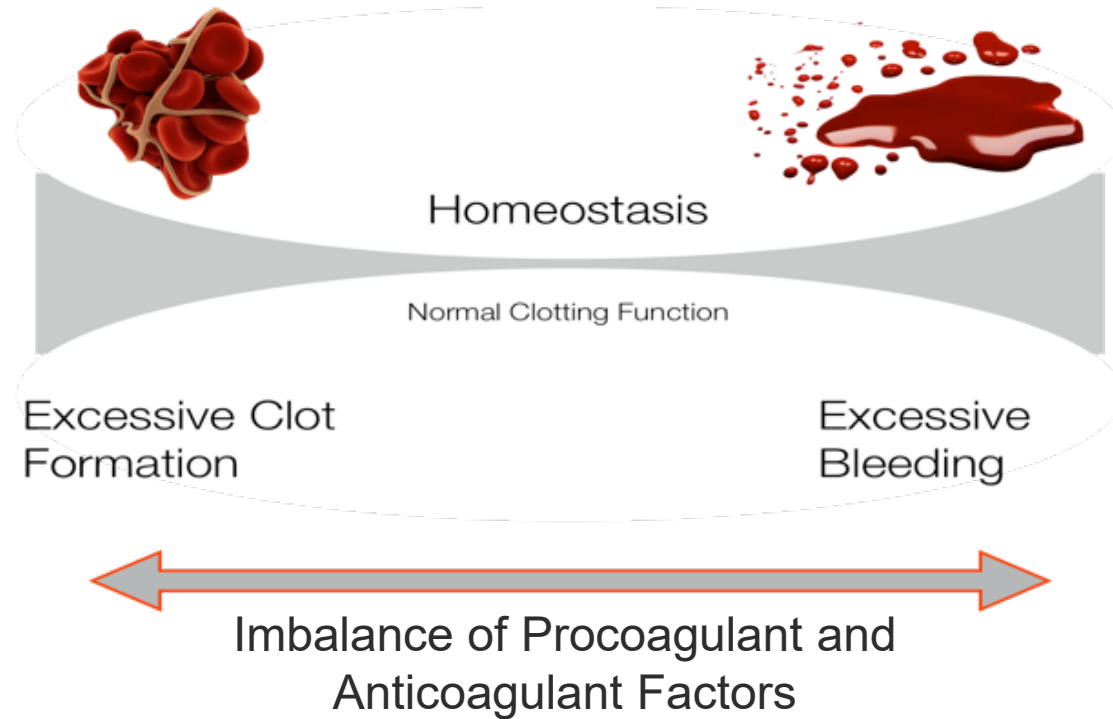
TIC is a spectrum of disrupted clotting function that ranges from excessive bleeding to excessive clotting



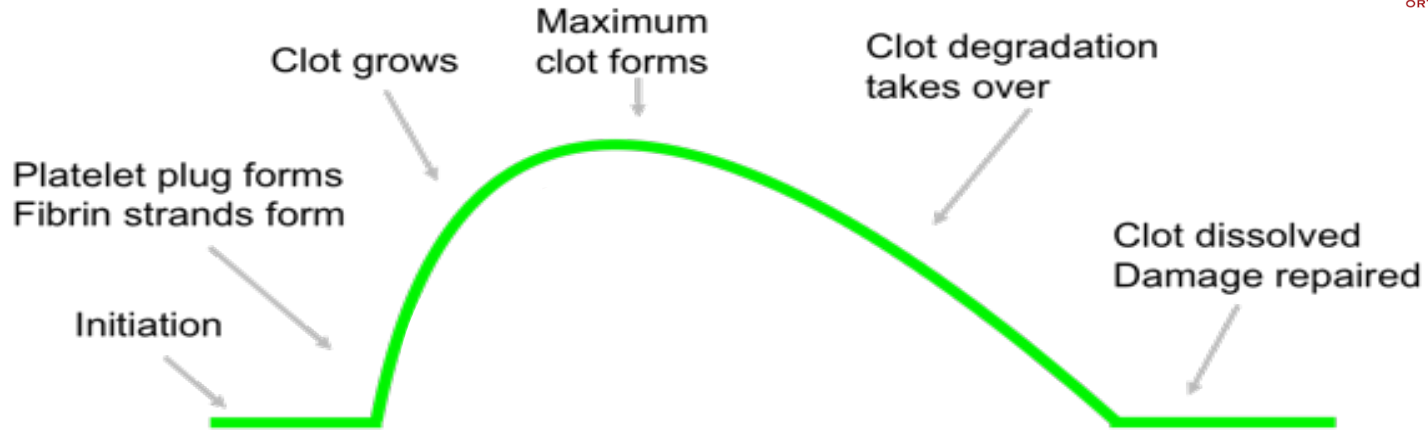
# Trauma-induced Coagulopathy

Hemorrhage is the leading cause of potentially survivable death after trauma

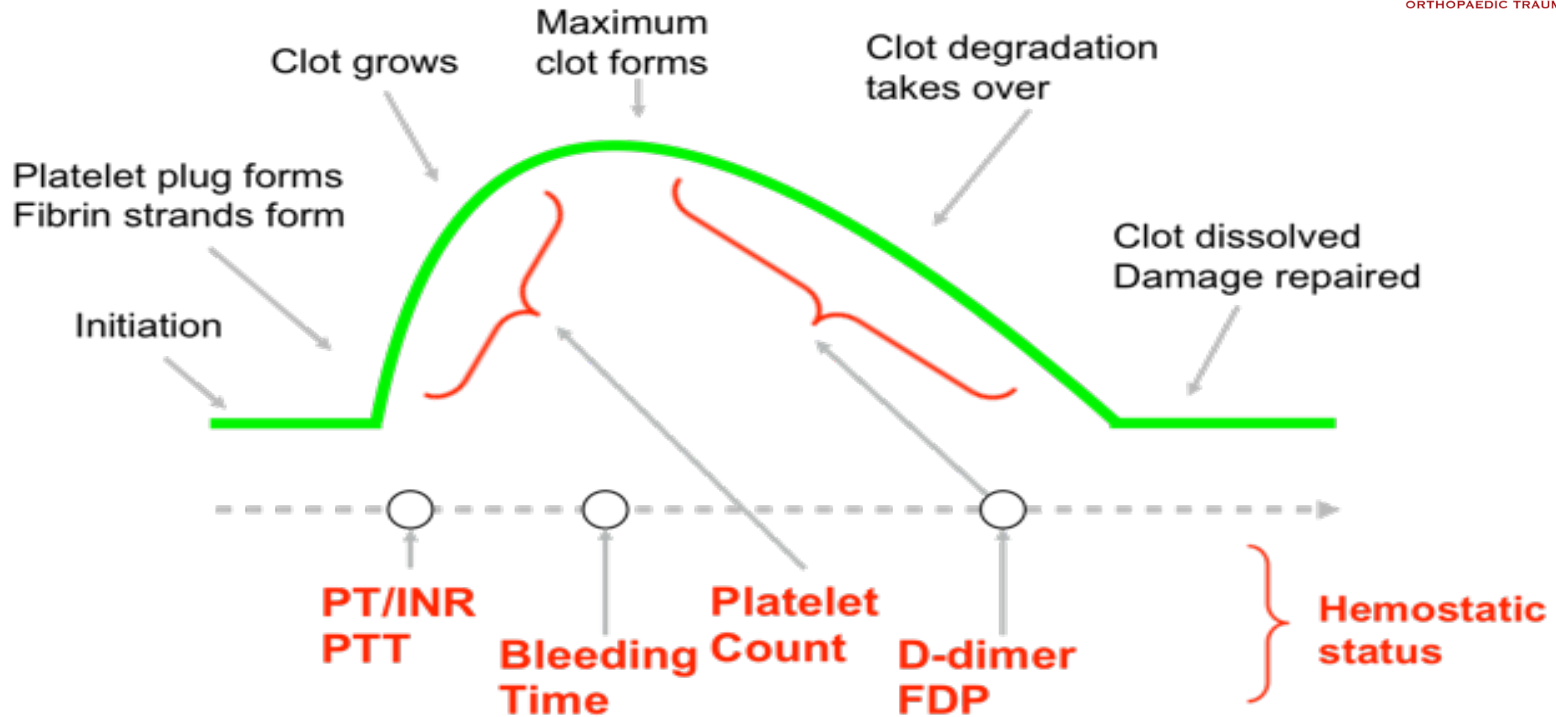
Venous thromboembolism remains a leading cause of morbidity and mortality following trauma



# Limitations of Conventional Coagulation Tests



# Limitations of Conventional Coagulation Tests



**Traditional Hemostasis Tests**

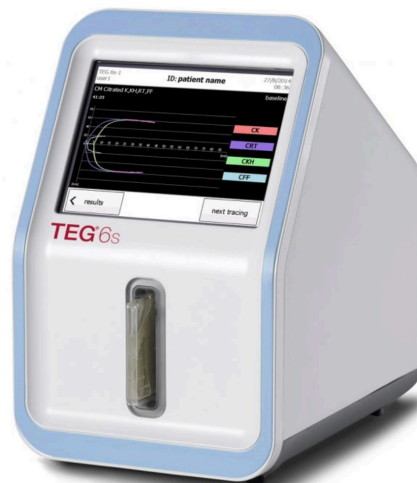


Do not define the overall process, just provide pieces of the process!

# Viscoelastic Assay - TEG

Thrombelastography (TEG) assesses whole blood (including platelets)

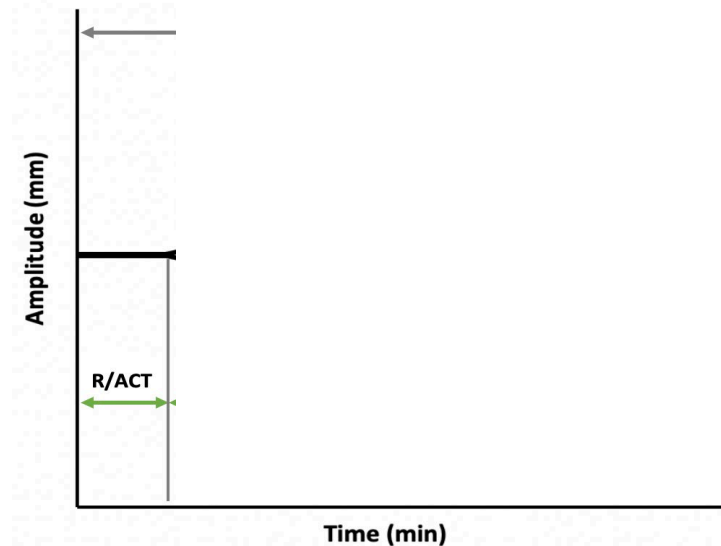
- Point-of-care tool
- Representation of what is happening *in vivo*





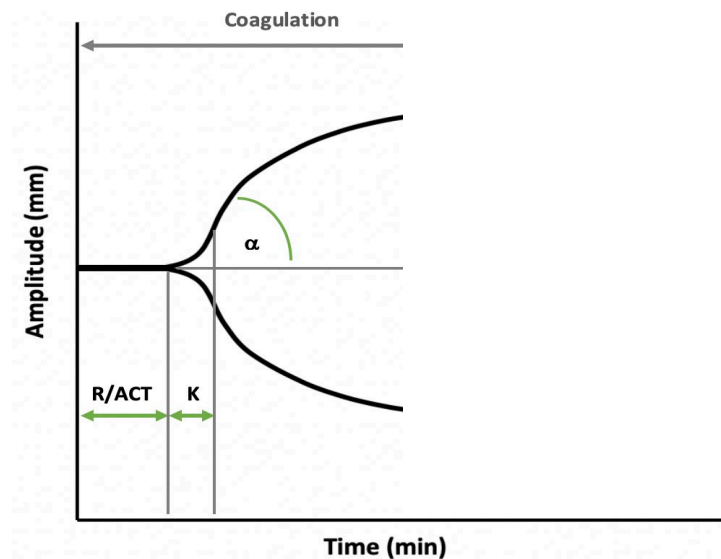
# Viscoelastic Assay - TEG

- Thrombelastography (TEG) is a whole-blood assay which provides a comprehensive analysis of:
  - **Clot initiation** (R-time, ACT)



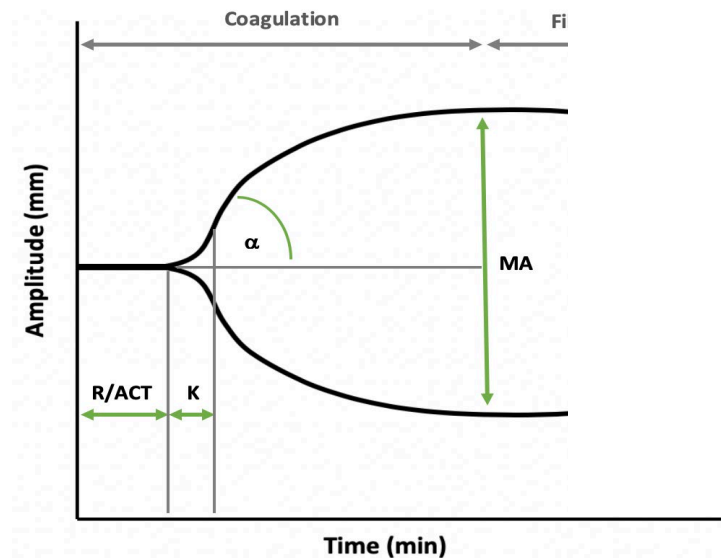
# Viscoelastic Assay - TEG

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  - **Clot initiation** (R-time, ACT)
  - **Clot propagation** (K-time,  $\alpha$ -angle)



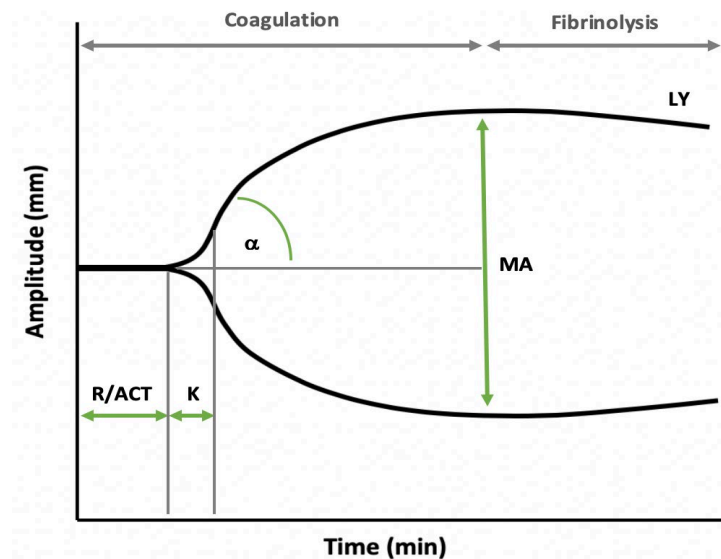
# Viscoelastic Assay - TEG

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  - **Clot initiation** (R-time, ACT)
  - **Clot propagation** (K-time,  $\alpha$ -angle)
  - **Clot strength** (Maximal Amplitude [MA])



# Viscoelastic Assay - TEG

- Thrombelastography (TEG) is a whole-blood assay which provides a comprehensive analysis of:
  - **Clot initiation** (R-time, ACT)
  - **Clot propagation** (K-time,  $\alpha$ -angle)
  - **Clot strength** (Maximal Amplitude [MA])
  - **Fibrinolysis** (LY-30)



# Therapeutic Strategies for Resuscitation


- **Goal-directed resuscitation based on TEG :**
  - Uses less plasma and platelet transfusions
  - Improves survival compared to massive transfusion protocols guided by conventional coagulation assessment
- Can be used to diagnose pathologies of fibrinolysis and guide treatment with tranexamic acid (i.e. >3% fibrinolysis)

# Burden of VTE

- ***Life-threatening*** thrombosis after injury continue to be devastating complications
  - Pulmonary embolism (PE) is a ***significant cause of preventable death***
  - Deep vein thrombosis (DVT) can cause significant dysfunction
- Major orthopaedic fracture is an independent risk factor for VTE
  - 7-fold increased risk for VTE, ***despite thromboprophylaxis***

## Stop the Clot, Spread the Word™

Blood clots can affect anyone, and blood clots can be prevented.

 ON AVERAGE, ONE AMERICAN DIES OF A BLOOD CLOT EVERY 6 MINUTES.

### UNDERSTANDING BLOOD CLOTS




A blood clot in one of the large veins, usually in a person's leg or arm, is called a **deep vein thrombosis** or **DVT**. When a blood clot like this forms, it can partly or completely block the flow of blood through the vein.

**If a DVT is not treated, it can move or break off and travel to the lungs.**

A blood clot in the lung is called a **pulmonary embolism** or **PE**, and can cause death and requires immediate medical attention.

### KNOW THE RISKS

Blood clots do not discriminate by age, gender, ethnicity or race. Blood clots can affect anyone. Three major risk factors are:

-  Cancer
-  Hospitalization & Surgery
-  Pregnancy

# Thromboprophylaxis: Agent & Duration?

- There is **no consensus on duration of thromboprophylaxis after major fracture**
  - 10 to 35 days of thromboprophylaxis has been suggested<sup>1-3</sup>
- There is currently **no evidence to support that one method of thromboprophylaxis is superior to others**<sup>4</sup>
- No consideration is given for sex- or age-based differences



1. Falck-Ytter et al. *Chest*. 2012;141(2):e278S-e325S. 2. Gee. *Br J Haematol*. 2019;186(5):792-793. 3. Lowe, Twaddle. *Scott Med J*. 2005;50(2):51-52. 4. Velmahos et al. *The American Surgeon*. 2004;70(10):893-896.

# Population-Based Thromboprophylaxis



**Highest** risk

Recommended prophylaxis:  
Pneumatic compression  
devices AND low dose  
heparin OR low molecular  
weight heparin

**10.7%** VTE risk

30 days total for duration of  
chemoprophylaxis



**32 yo male**  
**Isolated Ankle Injury**  
**Caprini Score = 11**

**72 yo female**  
**Isolated Ankle Injury**  
**Caprini Score = 13**



# TEG-based Hypercoagulability

**Thrombelastography (TEG) can measure increased VTE risk<sup>4-6</sup>**

Can Thrombelastography Predict Venous Thromboembolic Events in Patients With Severe Extremity Trauma?

*Joshua L. Gary, MD,\* Prism S. Schneider, MD, PhD,\* Matthew Galpin, RC,\*  
Zayde Radwan, MD,\* John W. Munz, MD,\* Timothy S. Achor, MD,\*  
Mark L. Prasarn, MD,\* and Bryan A. Cotton, MD†*

**Elevated MA = independent predictor  
of *in-hospital* VTE**

**MA > 65 mm (OR = 3.7, 95% CI 1.9-7.0)**

4. Gary, Schneider et al J Orthop Trauma. 2016 Jun; 30(6):294-8; 5. Brill et al J Trauma Acute Care Surg. 2017 Sep; 83(3):413-19; 6. Kashuk et al Surgery. 2009 Oct; 146(4):764-72

# TEG-based Hypercoagulability

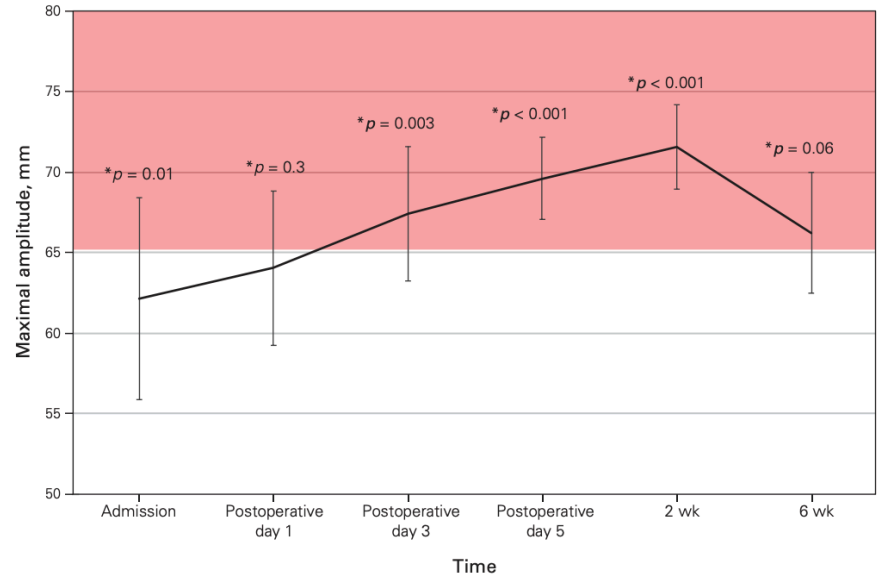
## Patients with hip fractures have prolonged hypercoagulability

HEALTH and FAITH studies (n = 2,520)  
**45.3%** of VTE occurred 6-weeks post-injury or later<sup>8</sup>

Daniel You, MD  
 Leslie Skeith, MD, MHPE  
 Robert Korley, MD  
 Paul Cattle, MD, MBT  
 Adrienne Lee, MD  
 Paul McBeth, MD, MASc  
 Braedon McDonald, MD, PhD  
 Richard Buckley, MD  
 Paul Duffy, MD  
 C. Ryan Martin, MD  
 Andrea Soo, PhD  
 Prism Schneider, MD, PhD

### Identification of hypercoagulability with thrombelastography in patients with hip fracture receiving thromboprophylaxis

Can J Surg 1 Jun; 64(3):E324-29



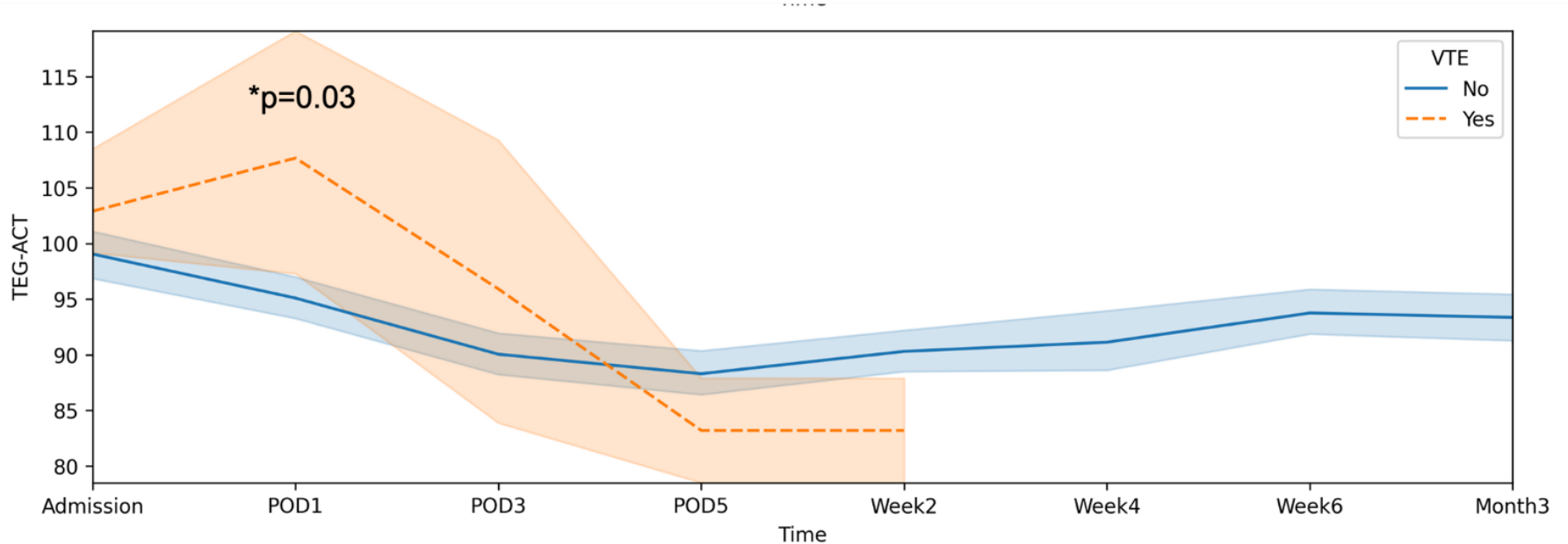
7. You et al Can J Surg. 2021 Jun; 64(3):E324-29;

8. MacDonald et al *J Orthop Trauma* **34**, S70–S75 (2020).

# TEG Can Identify Increased VTE Risk Early

n=271 patients with hip fractures, Mean Age = 79 years, 66% Female

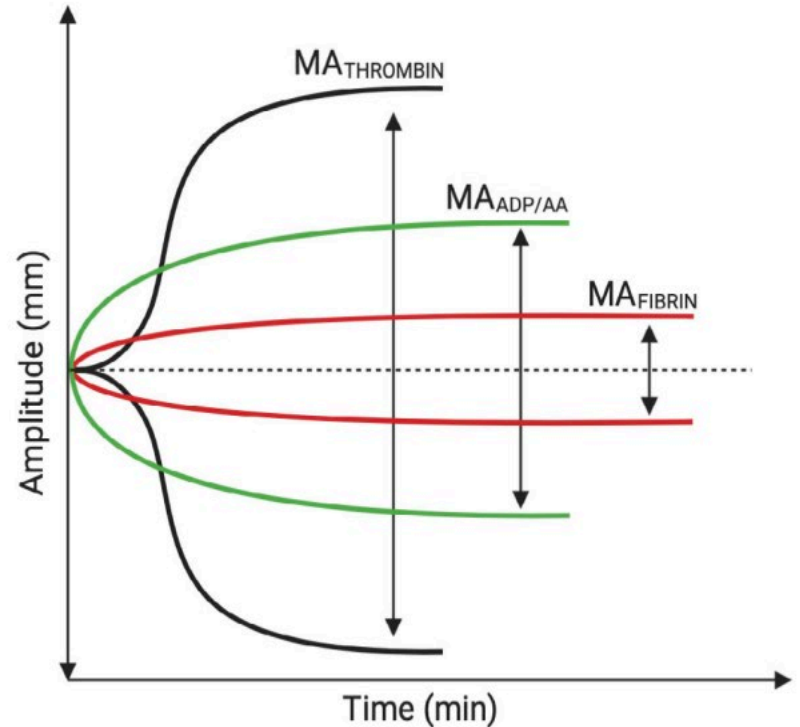
**Serial Activated Clotting Time (ACT) Between Patients with VTE and No VTE**



# Aspirin for Thromboprophylaxis?

## Thrombelastography Platelet Mapping (PLM)

- Factor XIII (Activator F) generates a fibrin cross-linked clot
  - Contribution of fibrin
- Addition of adenosine diphosphate (ADP)
  - Contribution of ADP receptors
- Addition of arachidonic acid (AA)
  - Contribution of thromboxane A<sub>2</sub> receptors



# Aspirin for Thromboprophylaxis?

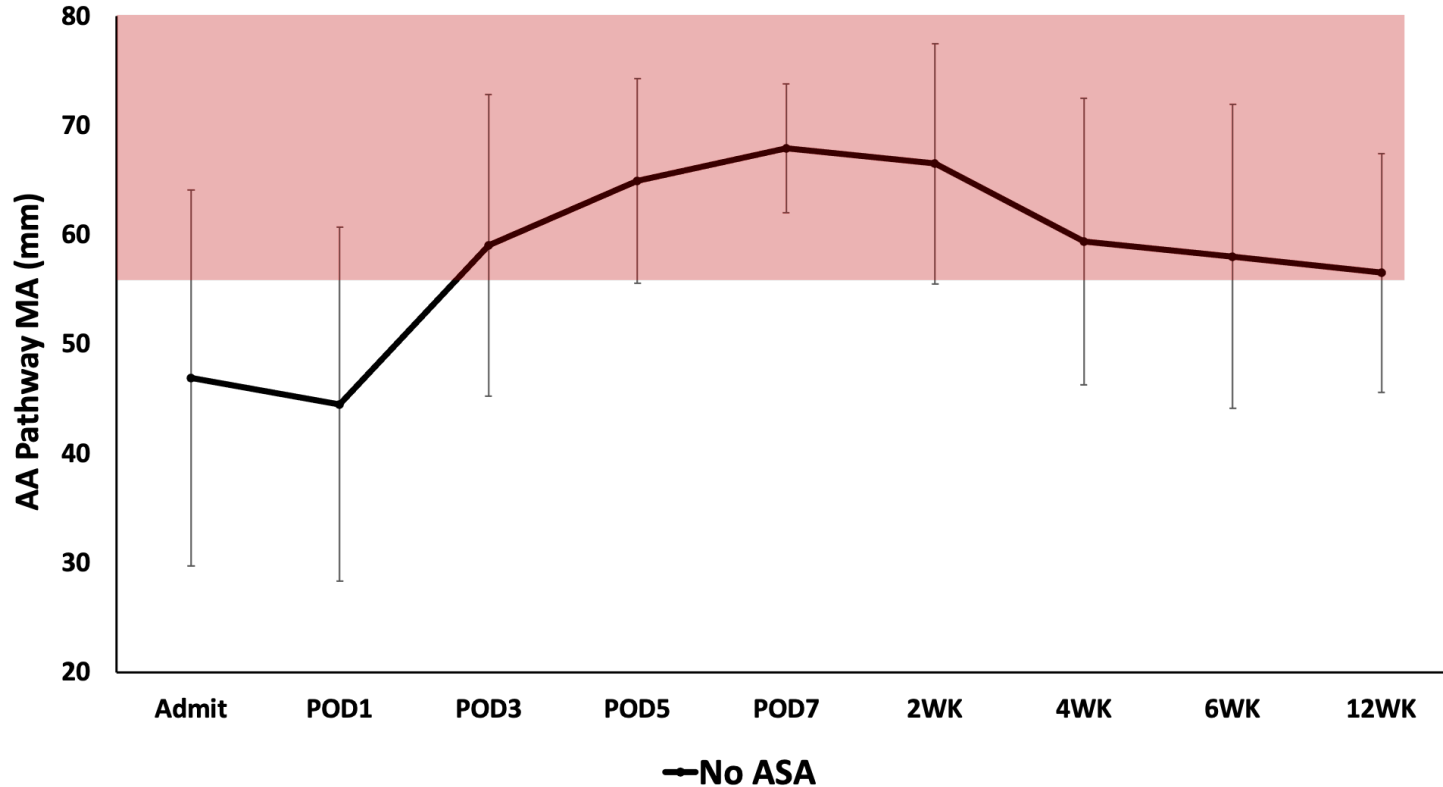


- N = 101; mean age = 77.3 (SD = 11.5) years; 65.3% female
- 18 participants (17.9%) received ASA post-operatively
- Remainder received LMWH

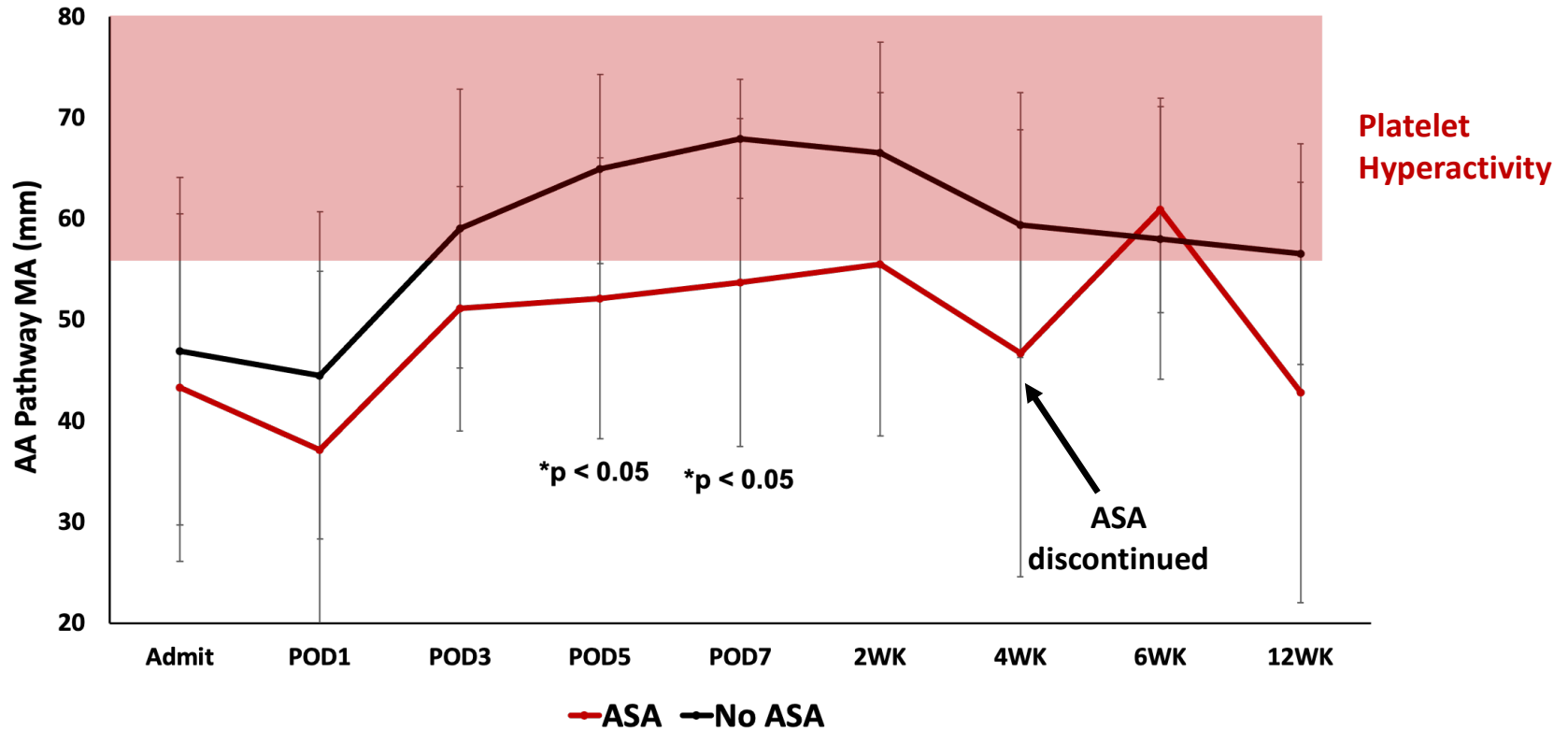


	ASA (n=18)	LMWH (n=83)	<i>p</i> -value
Age, mean (SD), years	77.0 (14.3)	77.4 (10.9)	0.912
Sex, female (%)	9 (50.0)	57 (68.7)	0.216
Surgery Type			1.000
Arthroplasty (%)	9 (50.0)	44 (53.0)	
Fixation (%)	9 (50.0)	39 (47.0)	

# Therapeutic Strategies for Thromboprophylaxis



# Therapeutic Strategies for Thromboprophylaxis



\* indicates significantly lower mean AA-MA for those on ASA

# Future Directions

- **Hypercoagulability and increased VTE risk is prolonged**
  - Maximum of 35 days of thromboprophylaxis commonly prescribed
- **Platelet Mapping supports platelet-mediated hypercoagulability**
  - AA and ADP pathways may be valuable therapeutic targets
  - Supports further investigation into safety and efficacy of antiplatelet use
- **Precision Medicine Approach to Trauma-induced Coagulopathy**



# Precision Medicine Approach to TIC

Assessment of individual risk should be made



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