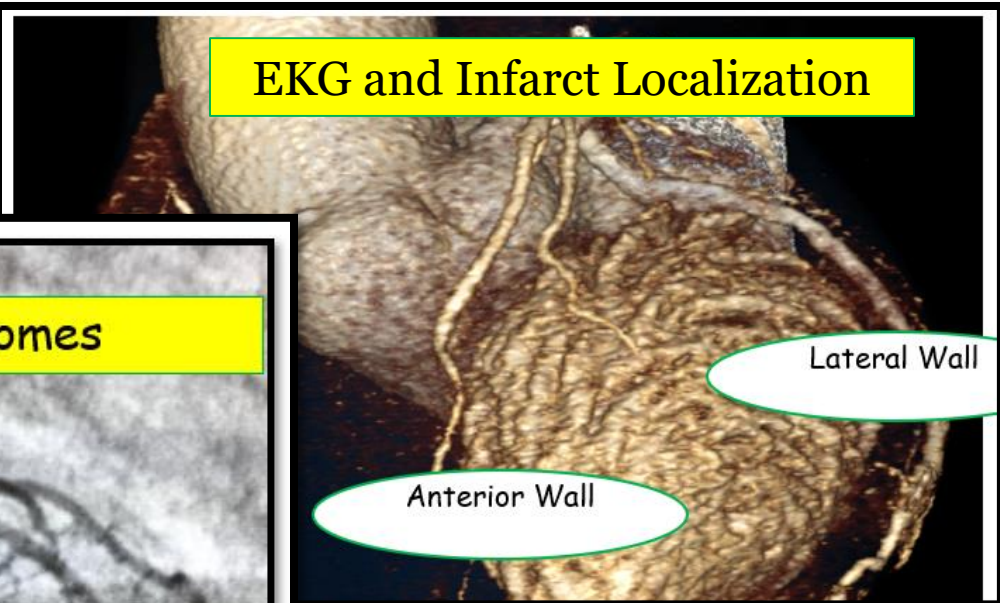


# Myocardial Infarction and Cardiac Pathology for USMLE Step One

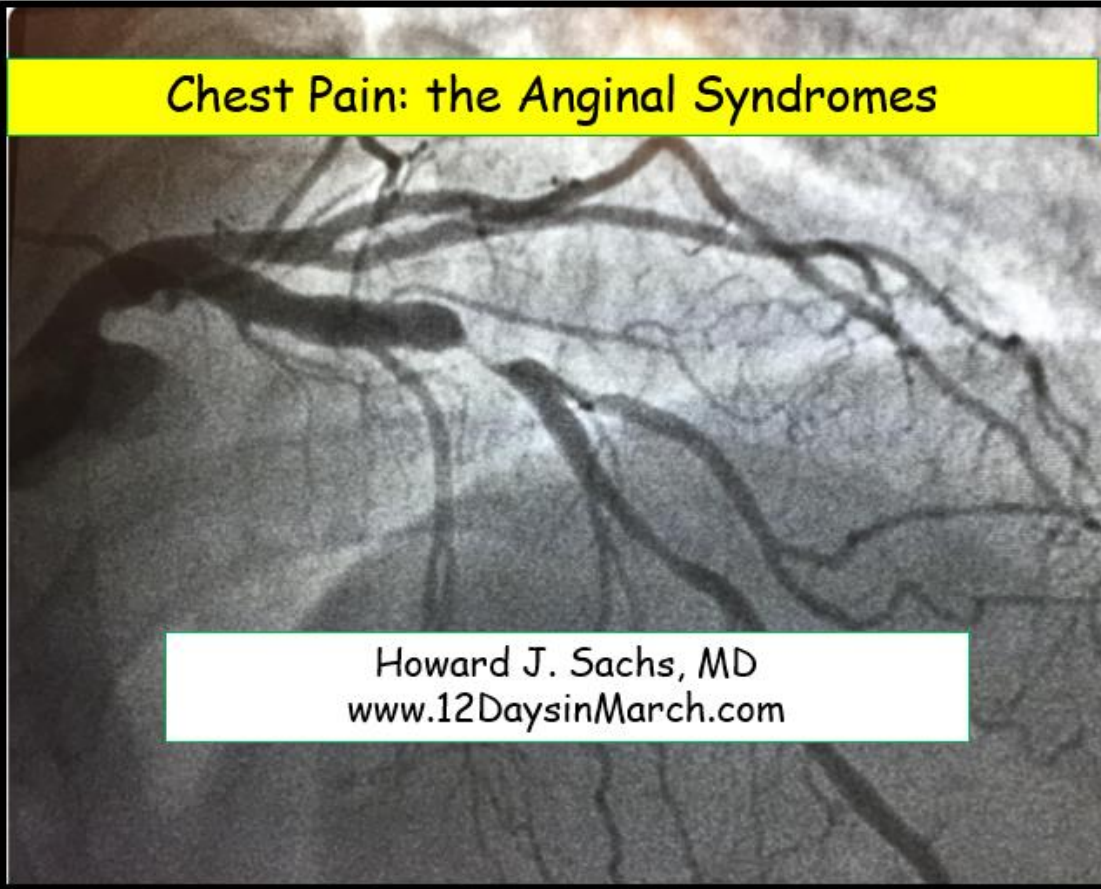


*Howard J. Sachs, MD*  
*Associate Professor of Medicine*  
*University of Massachusetts Medical School*  
[www.12DaysinMarch.com](http://www.12DaysinMarch.com)  
*E-mail: Howard@12daysinmarch.com*

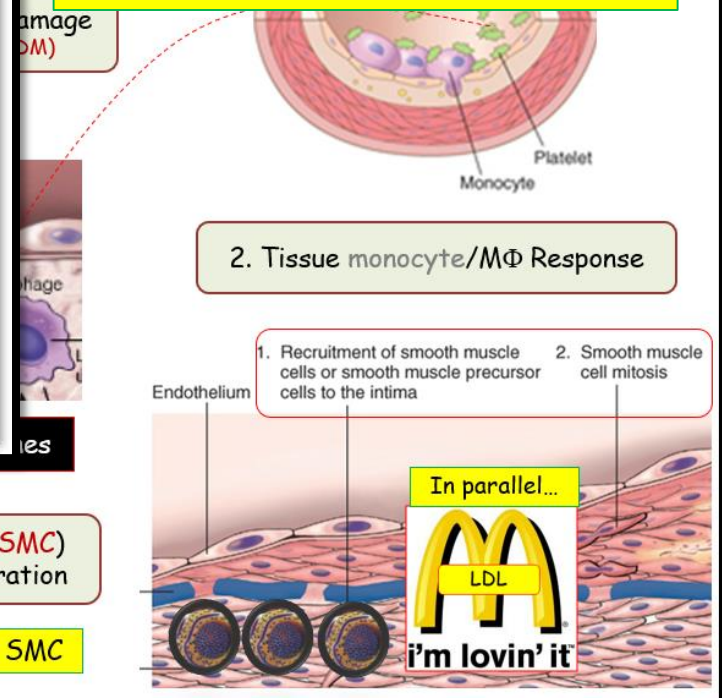
## EKG and Infarct Localization



## Chest Pain: the Anginal Syndromes



## Atherogenesis

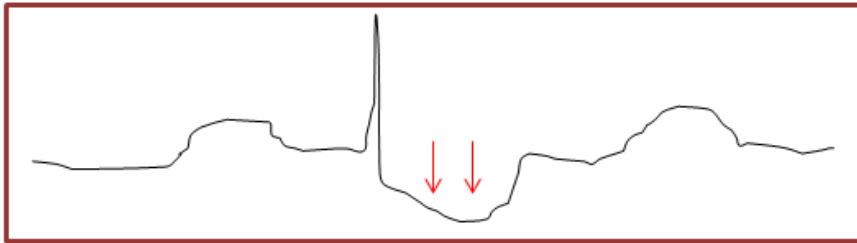


3. Smooth muscle (SMC) migration & proliferation

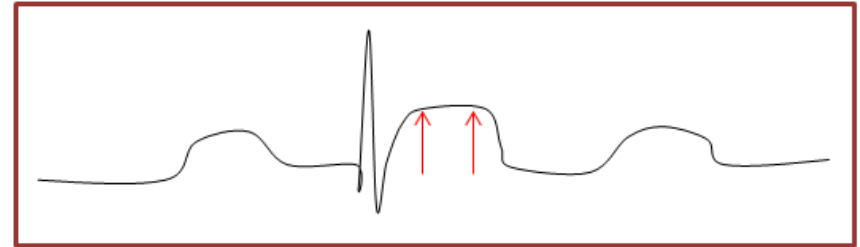
Foam Cells: MΦ and SMC

# Infarction

**NSTEMI**  
(**Subendocardial** or  
Non-Q wave infarction)



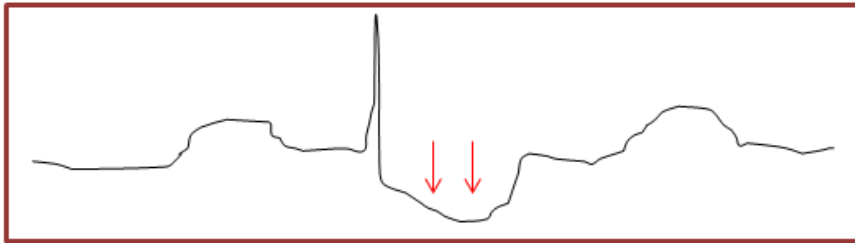
**STEMI**  
(**Transmural** or  
Q wave infarction)



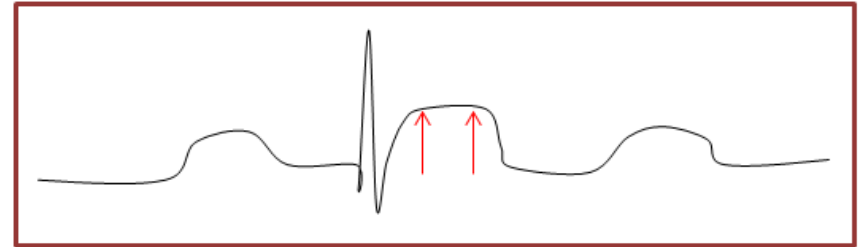
Definition (for USMLE):  
*Clinical features, Diagnostic EKG and Biomarker Elevation*

# Infarction

**NSTEMI**  
(**Subendocardial** or  
Non-Q wave infarction)



**STEMI**  
(**Transmural** or  
Q wave infarction)



## CK-MB

– Detect in 3-4h, pk 10-12h, 100% sens 8-12h, dur 2-4d

## Troponin I

– Detect 2-4h, pk 10-24h, 100% sens 5-10h, dur 5-10d

## Infarction

*As biomarkers elevate by 4 hours, a patient can experience sudden cardiac death (SCD) without demonstrating evidence of myocardial injury.*

### CK-MB

– Detect in 3-4h, pk 10-12h, 100% sens 8-12h, dur 2-4d

### Troponin I

– Detect 2-4h, pk 10-24h, 100% sens 5-10h, dur 5-10d

## Infarction

### CK-MB

- Detect in 3-4h, pk 10-12h, 100% sens 8-12h, dur 2-4d

### Troponin I

- Detect 2-4h, pk 10-24h, 100% sens 5-10h, dur 5-10d

# Infarction

NSTEMI  
(Subendocardial or  
Non-Q wave infarction)

STEMI  
(Transmural)

Troponin I

– Detect 2-4h,

100% sens 5-10h.

48 y.o. presents to ER (1200) with severe nausea and heartburn.  
Partially relieved with GI cocktail (Maalox, lidocaine).

Troponin and EKG on admission to ER are negative.  
ER discharge (1600). Arrests at home 4 h later.

# Infarction

*Niche Derivative for CK*

## CK-MB

– Detect in 3-4h, pk 10-12h, 100% sens 8-12h, dur 2-4d

## Troponin I

– Detect 2-4h, pk 10-24h, 100% sens 5-10h, dur 5-10d



## Infarction

Patient presented with MI. Three days later, he is having recurrent chest pain. Which is the best test to determine *extension of MI*?

1. CK-MB
2. Troponin

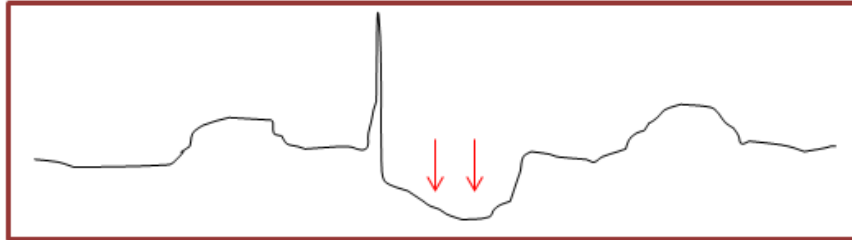
### CK-MB

– Detect in 3-4h, pk 10-12h, 100% sens 8-12h, dur 2-4d

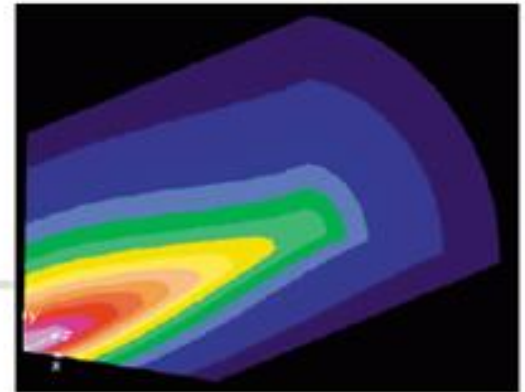
### Troponin I

– Detect 2-4h, pk 10-24h, 100% sens 5-10h, dur 5-10d

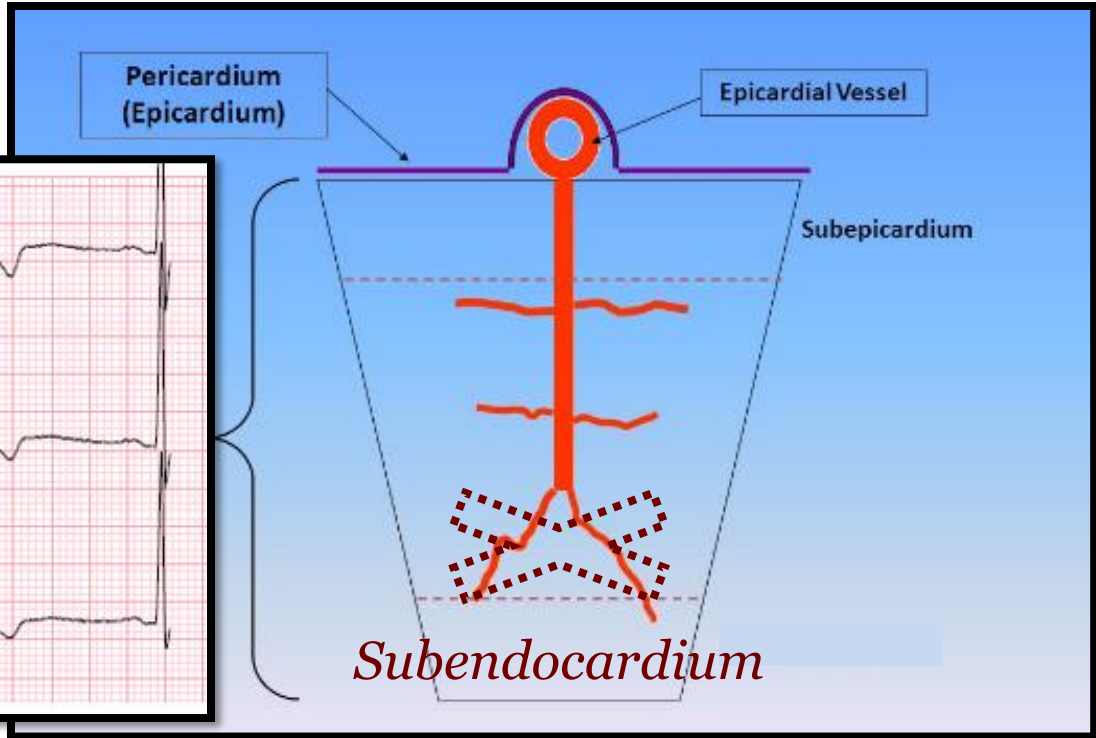
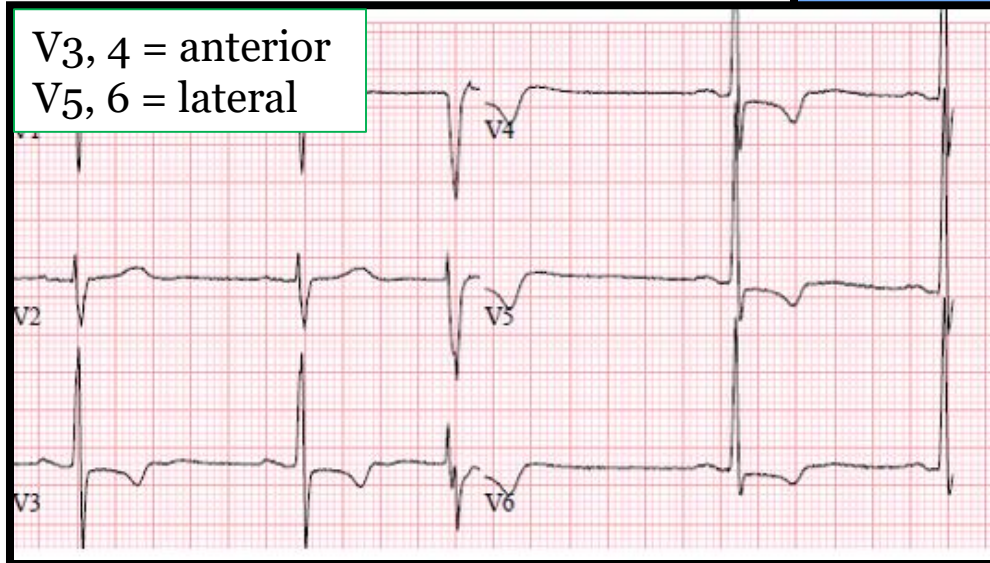
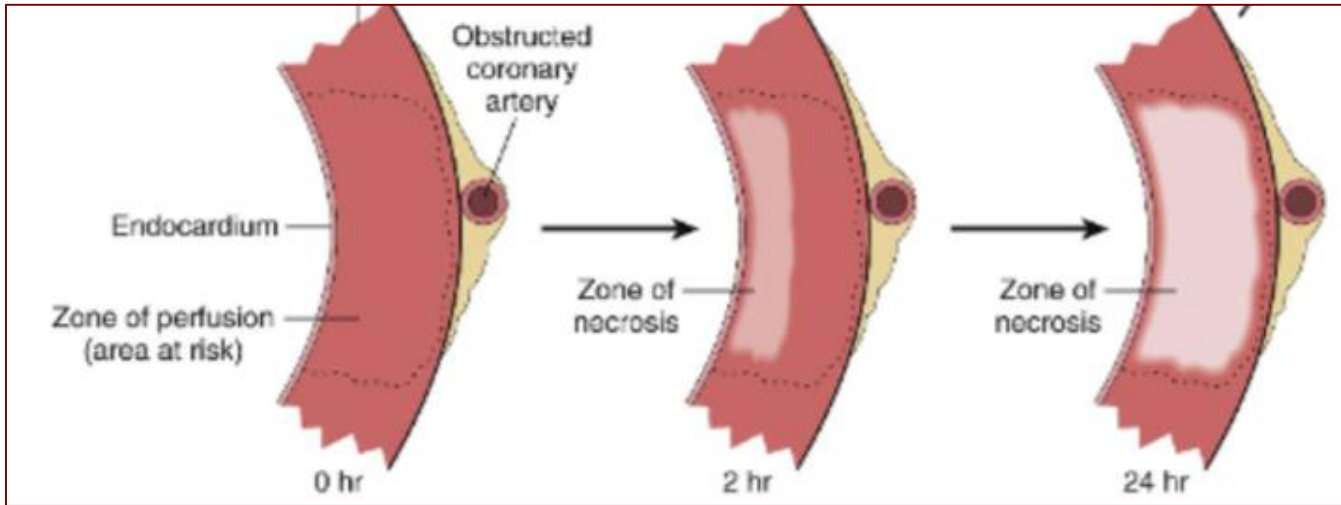
NSTEMI  
(Subendocardial or  
Non-Q wave infarction)



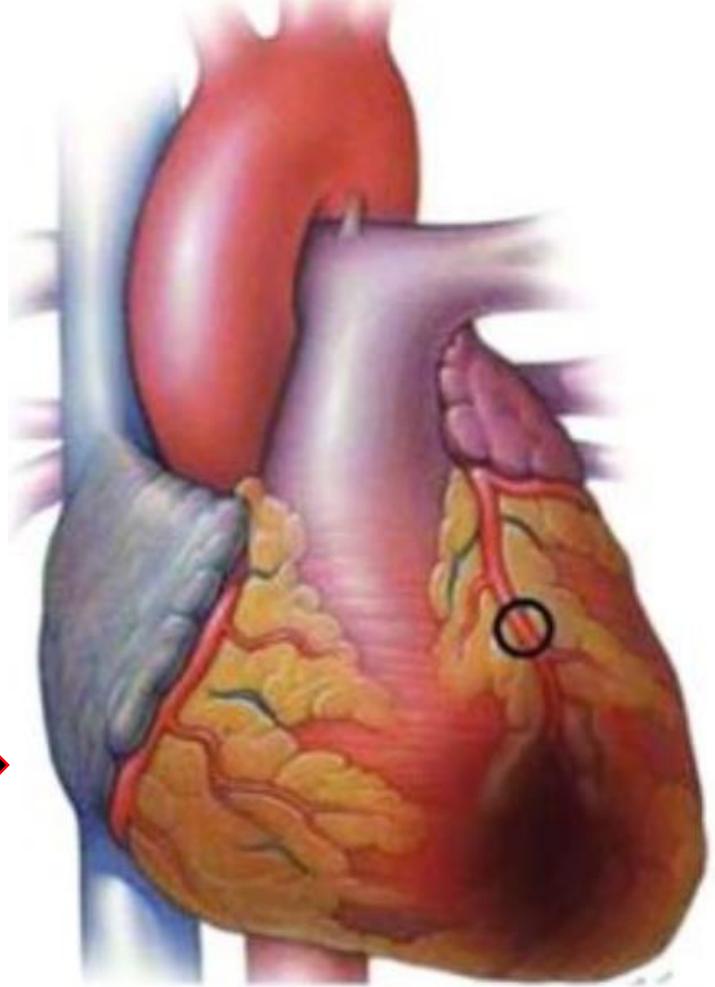
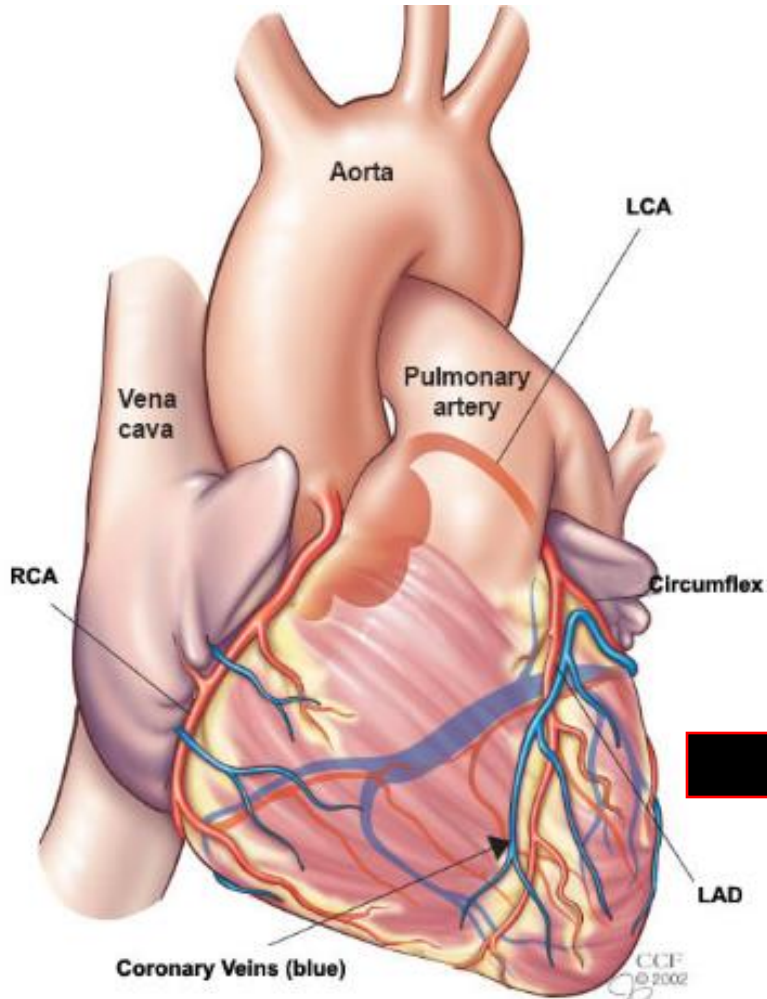
The *wavefront*  
phenomenon



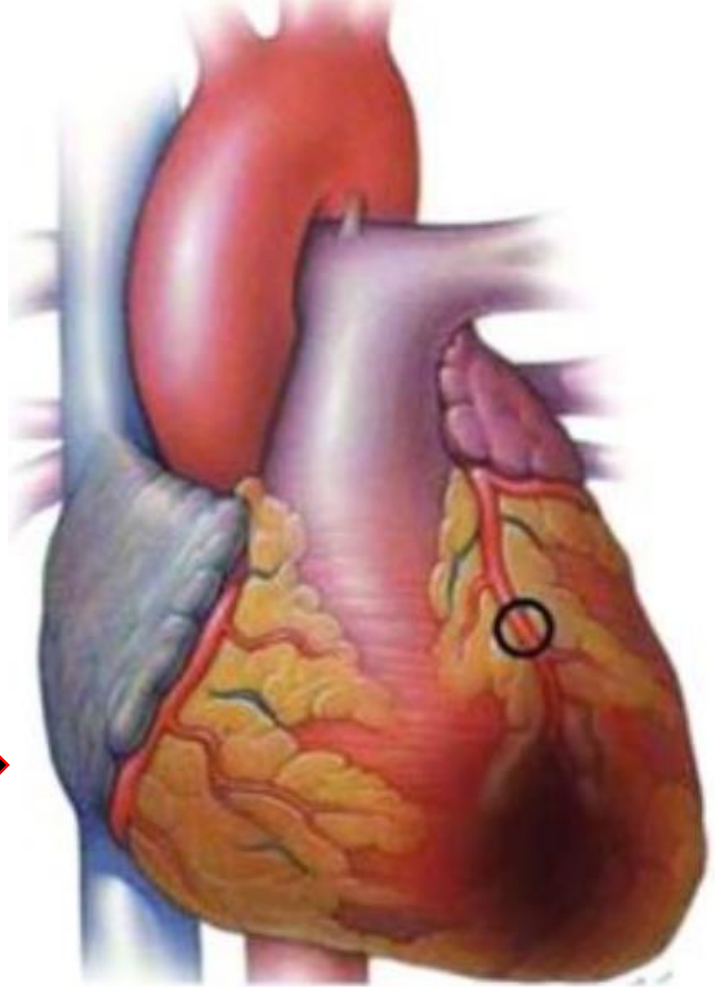
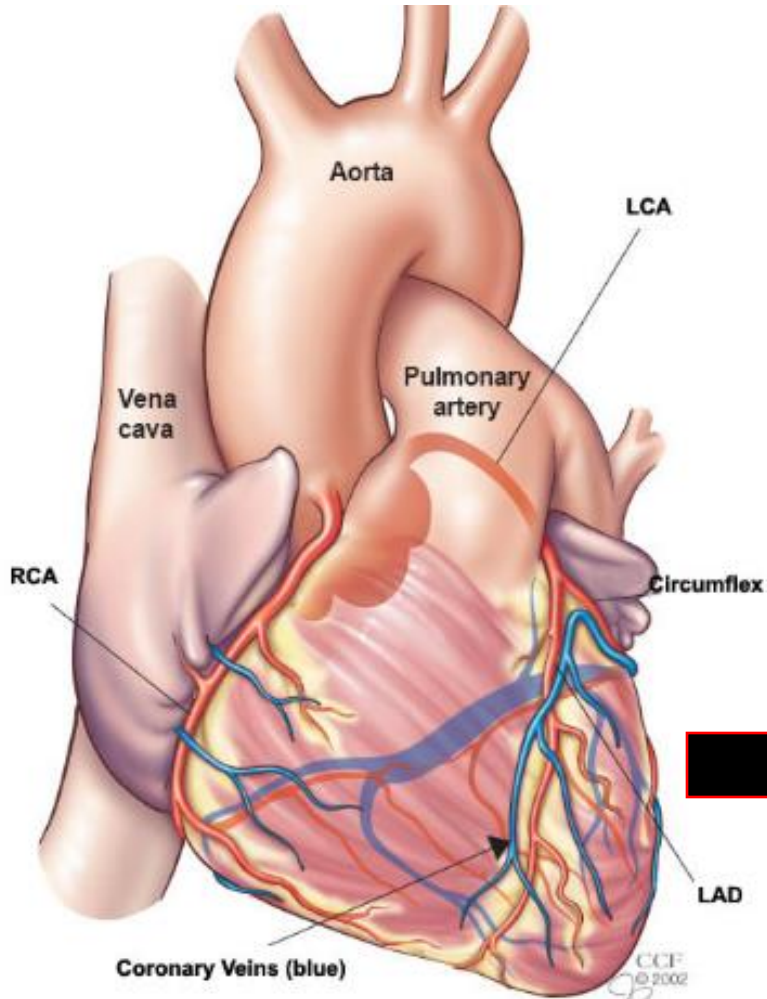
- Necrosis begins in a small zone of the myocardium beneath the endocardial surface, in the center of the ischemic zone.



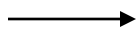
# Pathology of Myocardial Infarction



# Pathology of Myocardial Infarction

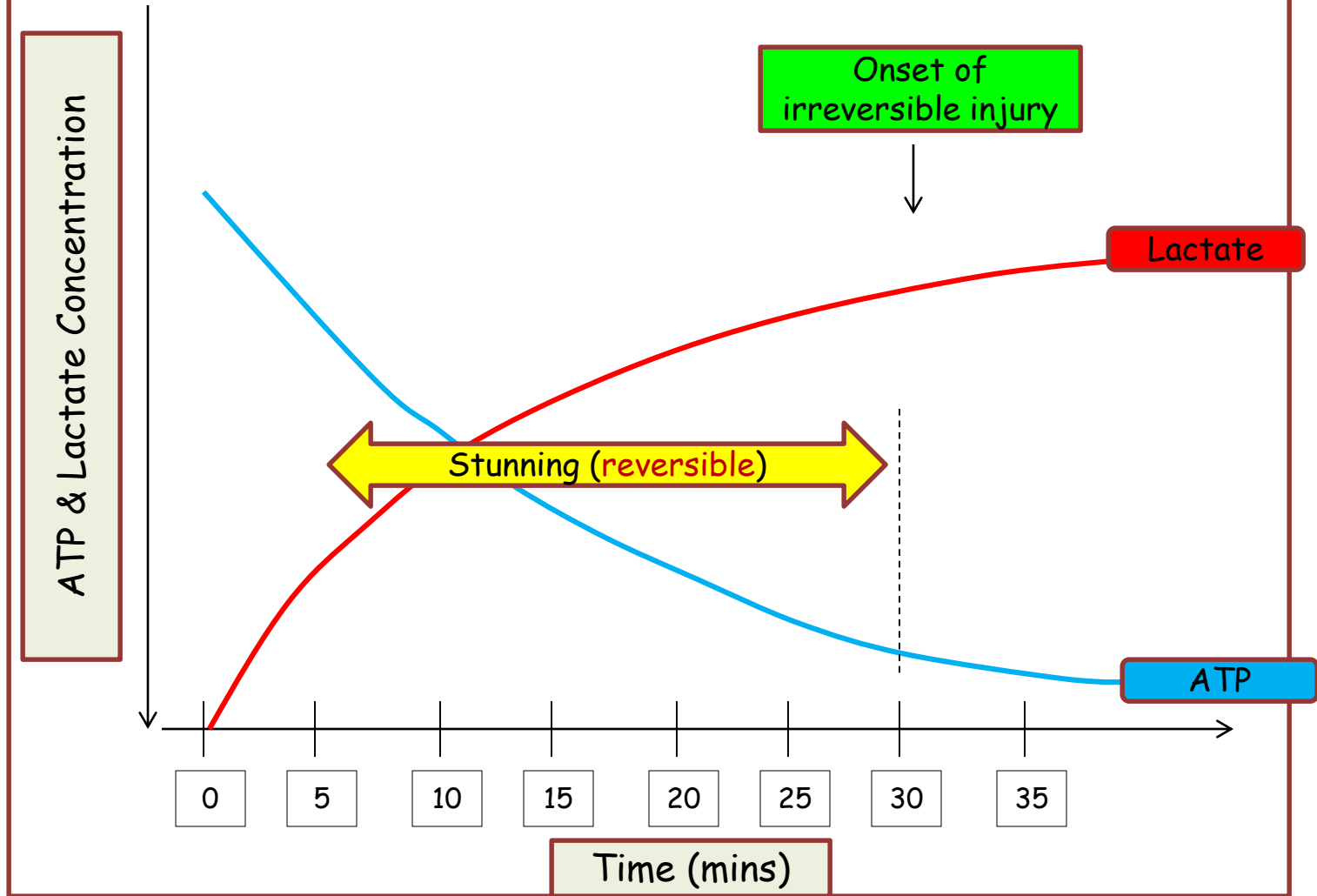


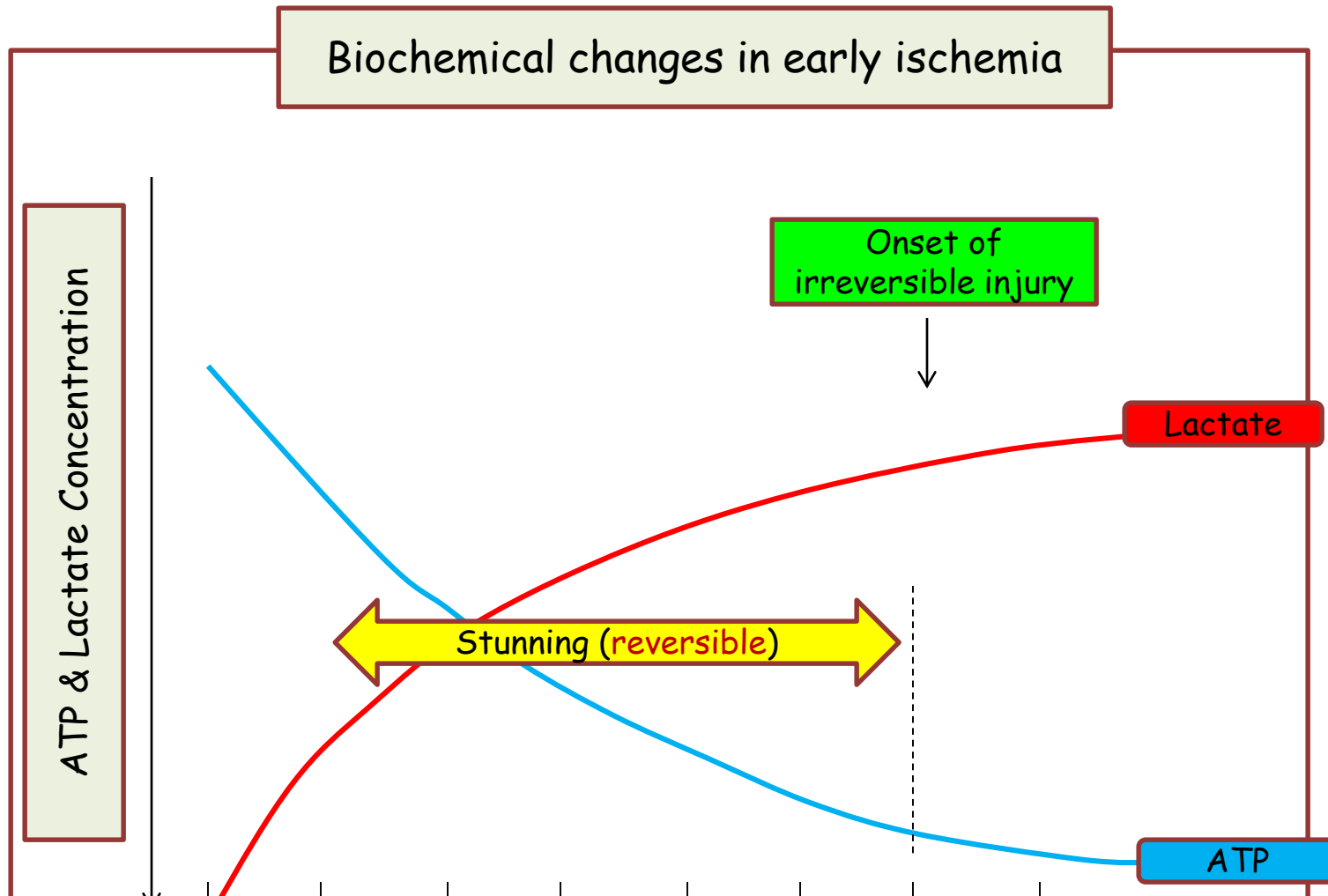
120 seconds



20-30 mins

# Biochemical changes in early ischemia

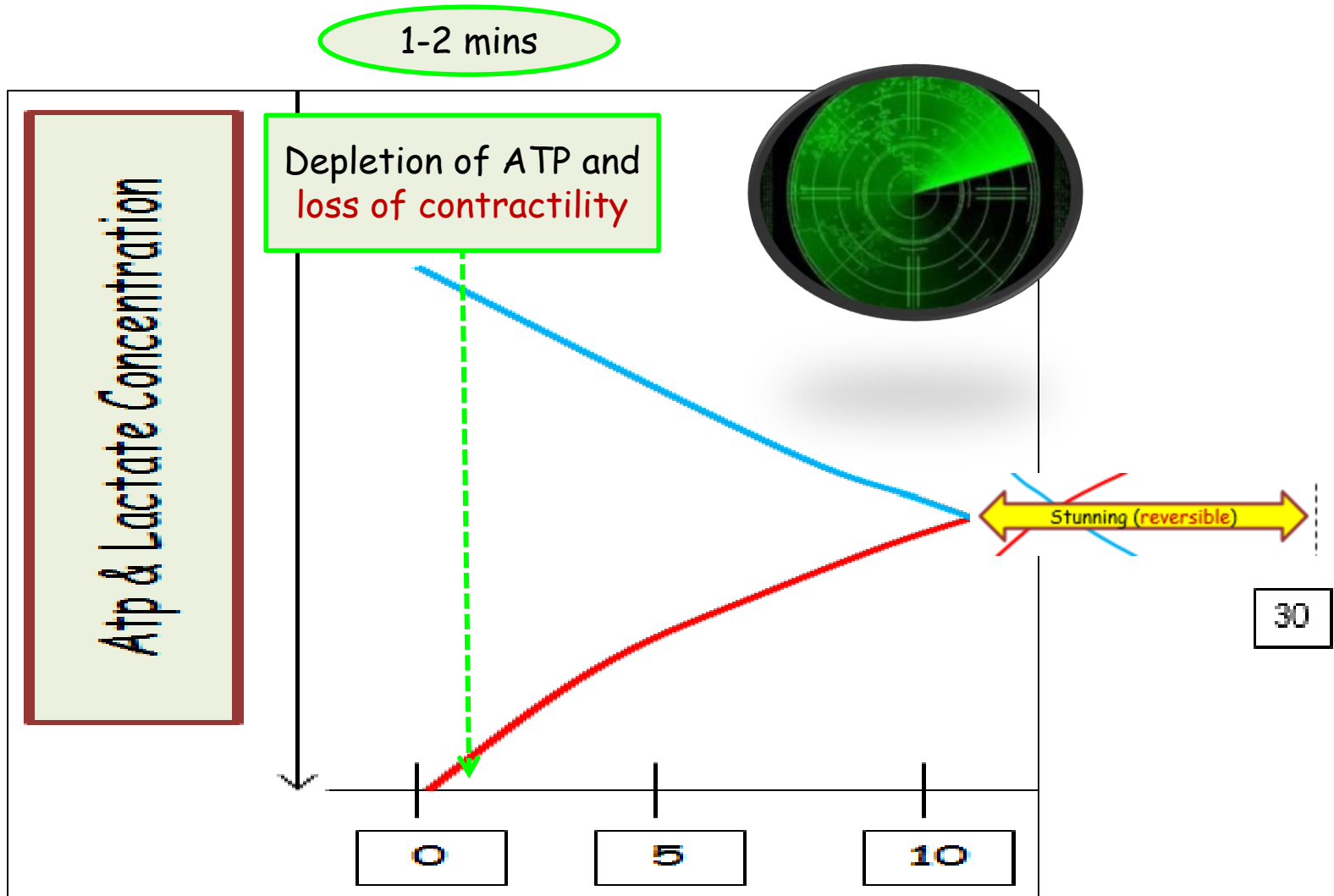




Do Not Confuse: Stunning versus Hibernating

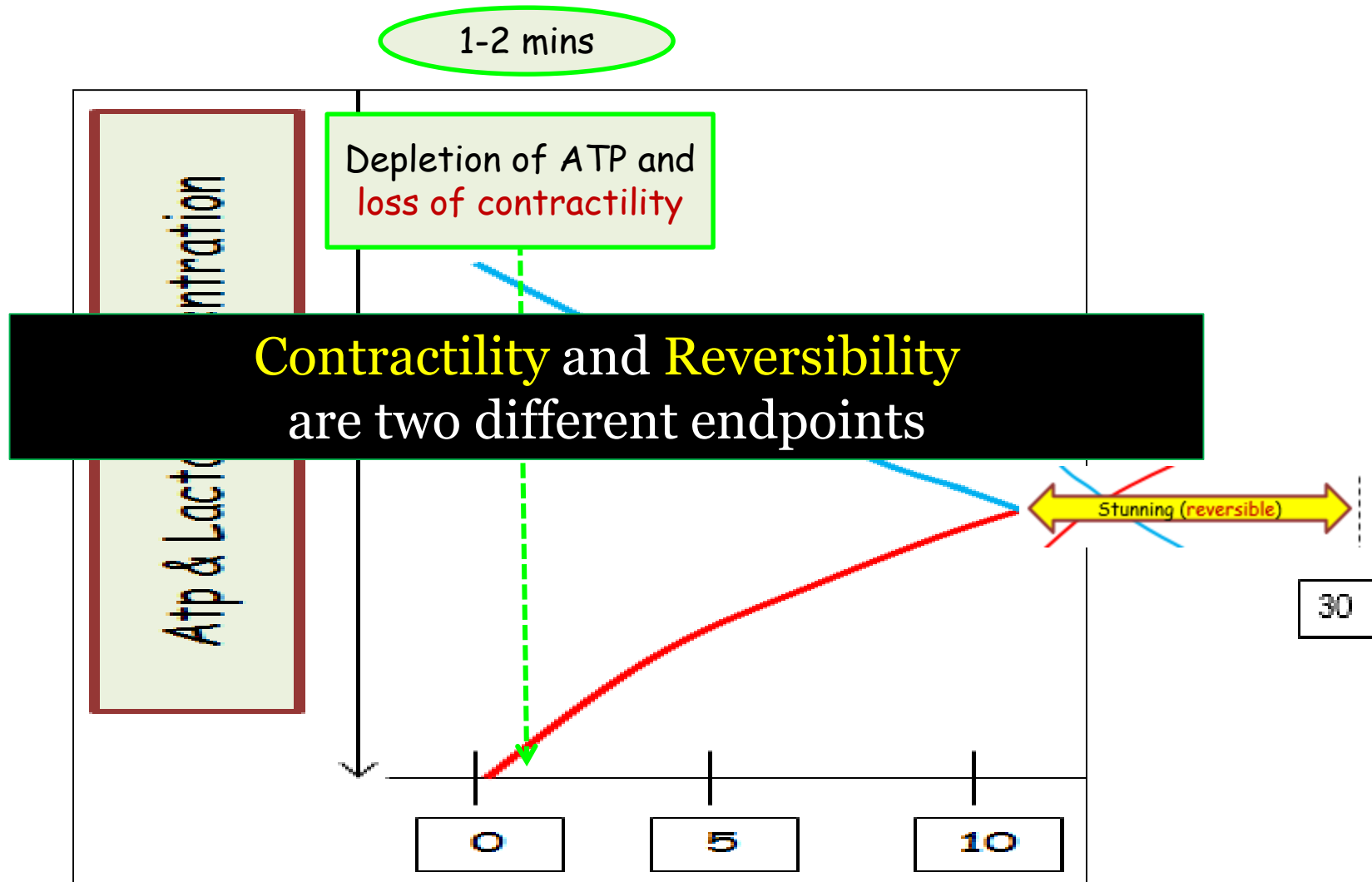
Stunning – transient post-ischemic dysfunction (acute)

Hibernating – refers to the diminished LV function ( $\downarrow$  EF%) that follows *multiple low-grade ischemic events*; chronic, but potentially reversible, ischemic dysfunction following revascularization



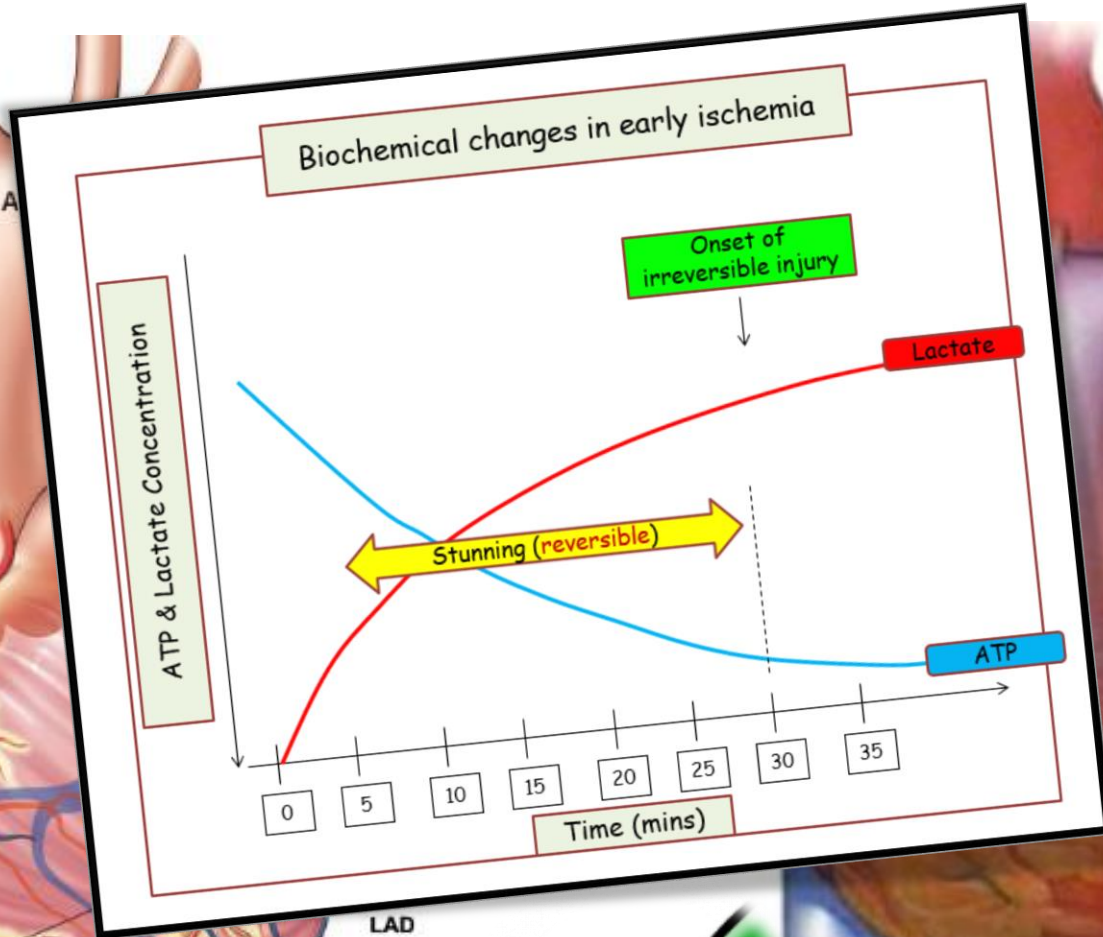
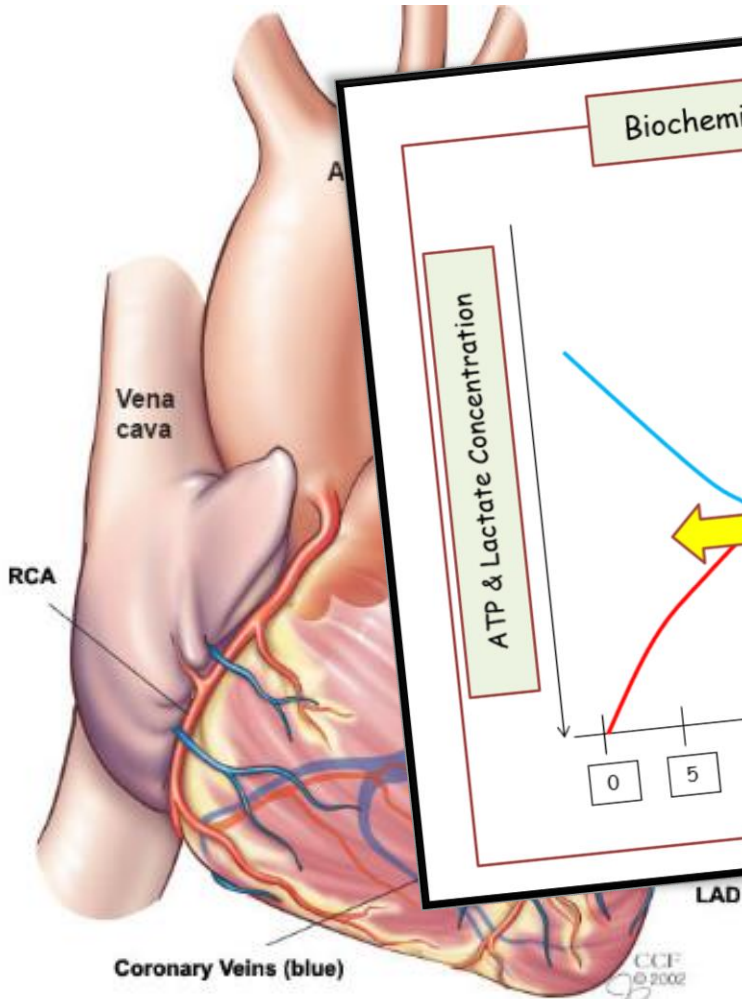
Pick the point on the curve where the myocardium stops contracting?



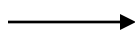


Pick the point on the curve where the myocardium stops contracting?

Answer: 120 secs

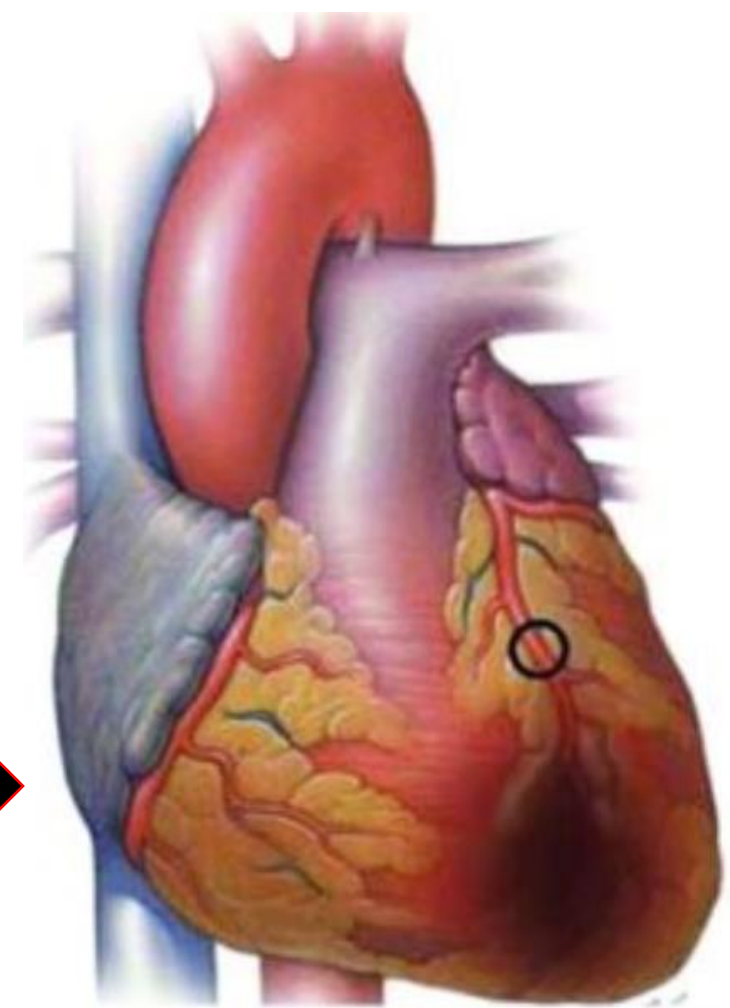
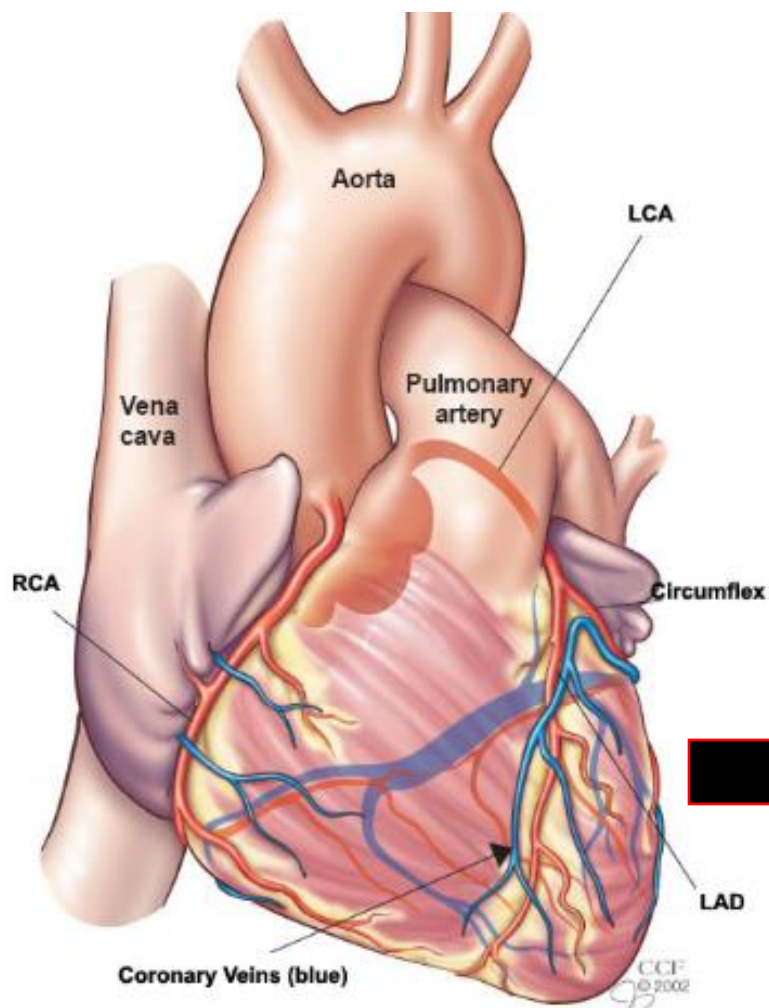


120 seconds



20-30 mins





120 seconds

20-30 mins

0-6 hours

# Cardiac Pathology

0-6h

Injury

Complications

Microscopy

---

# Cardiac Pathology

Injury

Complications

Microscopy



0-6h



What cardiac pathology can you expect in the first 6 hours?

# Cardiac Pathology

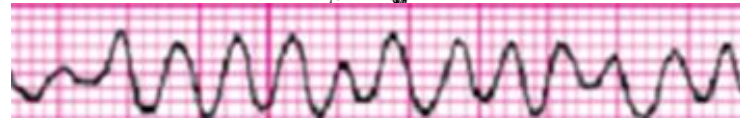
Injury

Complications

Microscopy



0-6h



What cardiac pathology can you expect in the first 6 hours?

Answer: None

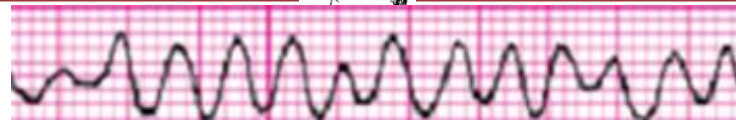


## Cardiac Pathology

Injury

Complications

Microscopy



What cardiac pathology can you expect in the first 6 hours?

Answer: None

0-6h

*Proximal coronary occlusions can cause arrhythmogenic deaths **before evidence of coagulative necrosis develops.***

# Cardiac Pathology

Injury

Complications

Microscopy

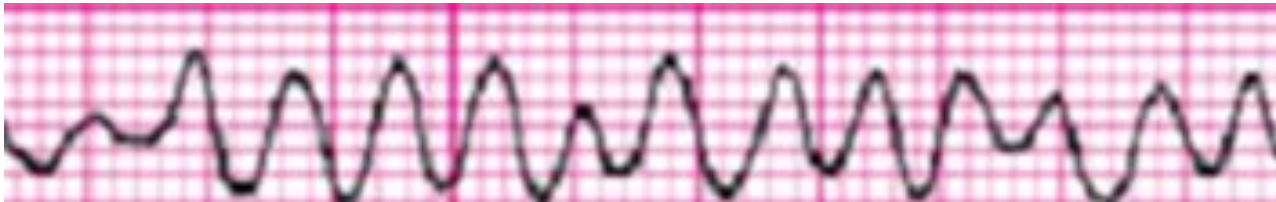


0-6h



*Suspend Reality (for Step One):*

*Link fatal cardiac arrhythmias with the initial six hours of myocardial necrosis*





# Cardiac Pathology

Injury

Complications

Microscopy

0-6h



Patient develops CP and dies one hour later.  
What was the most likely cause of death?

## Cardiac Pathology

Injury

Complications

Microscopy



0-6h



*Patient develops CP and dies one hour later.  
What was the most likely cause of death?*

48 y.o. presents to ER with severe nausea and heartburn.  
Partially relieved with GI cocktail (Maalox, lidocaine).  
Troponin and EKG on admission to ER are negative.  
Arrests at home 4 h later.

**Which of the following was seen grossly/histologically?**

## Cardiac Pathology

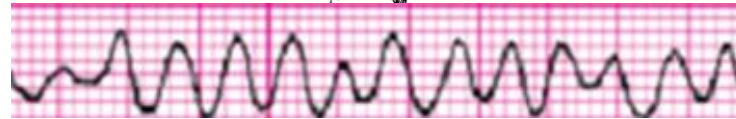
Injury

Complications

Microscopy



0-6h



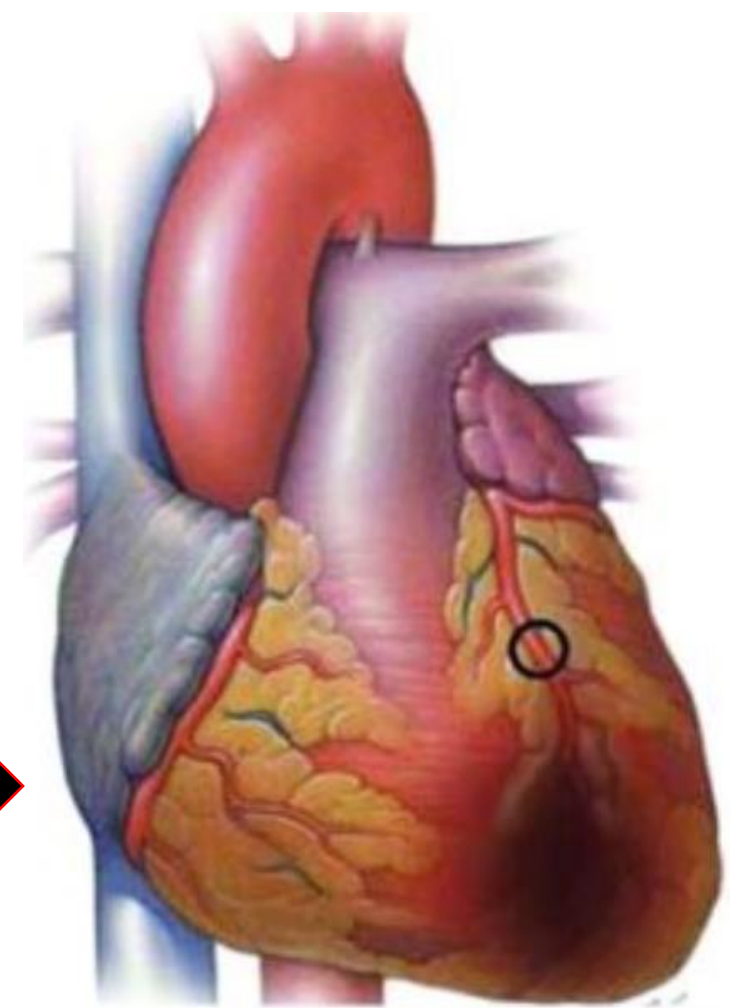
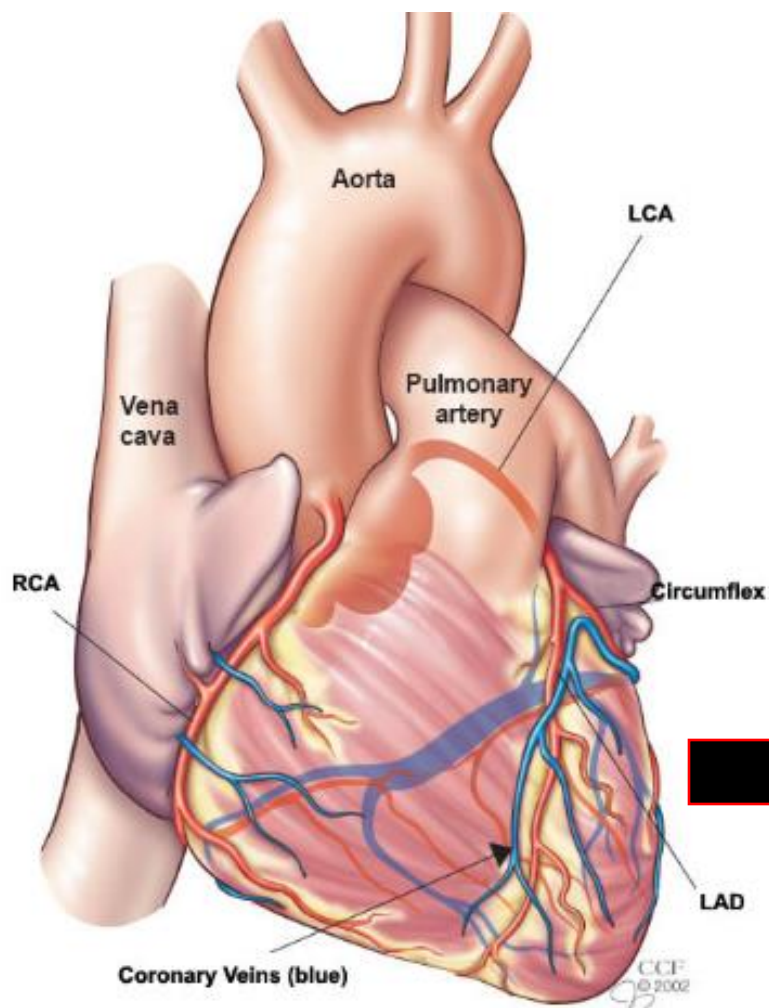
*Patient develops CP and dies. Most likely cause of death?*

48 y.o. presents to ER with severe nausea and heartburn.  
Partially relieved with GI cocktail (Maalox, lidocaine).  
Troponin and EKG on admission to ER are negative.  
Arrests at home 4 h later.

Which of the following was seen grossly/histologically?

Answer: Normal Tissue

[no histopathologic (*coagulative necrosis*) changes during initial presentation]



120 seconds

20-30 mins

0-6 hours

1-3 days

# Cardiac Pathology

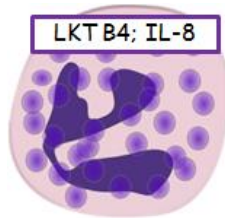
Injury

Complications

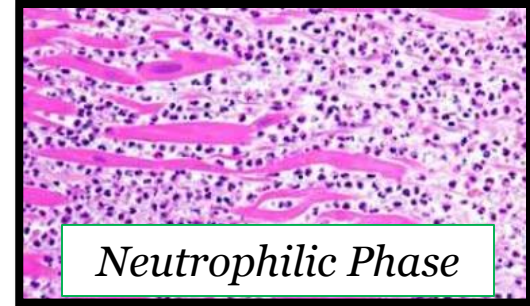
Microscopy

1-3 d

LKT B4; IL-8



Fibrinous  
Pericarditis



*Neutrophilic Phase*

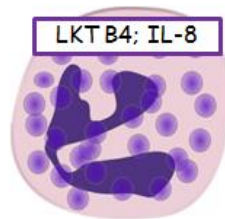
# Cardiac Pathology

Injury

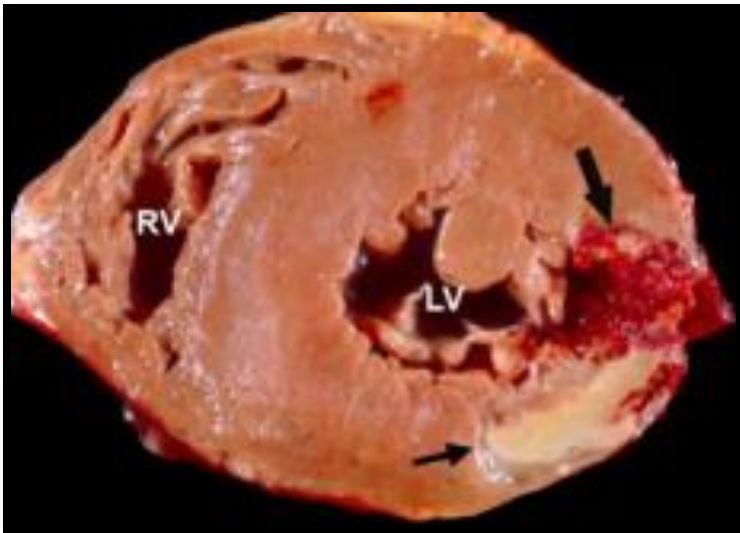
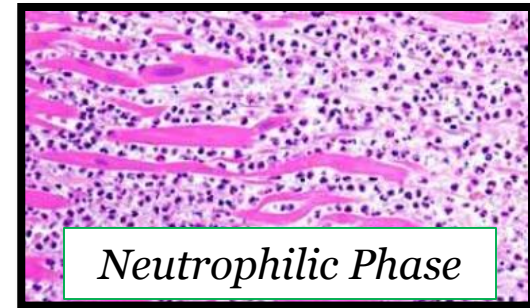
Complications

Microscopy

1-3 d



Fibrinous  
Pericarditis



Old woman found dead at home clutching  
bottle of SL NTG.

Autopsy reveals **neutrophilic infiltrate**.

When did she kick it?

- A. 1 hr ago
- B. 1 day ago
- C. 1 week ago

*Derivative One*

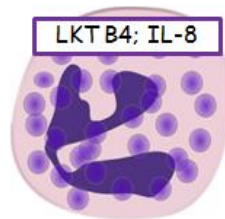
# Cardiac Pathology

Injury

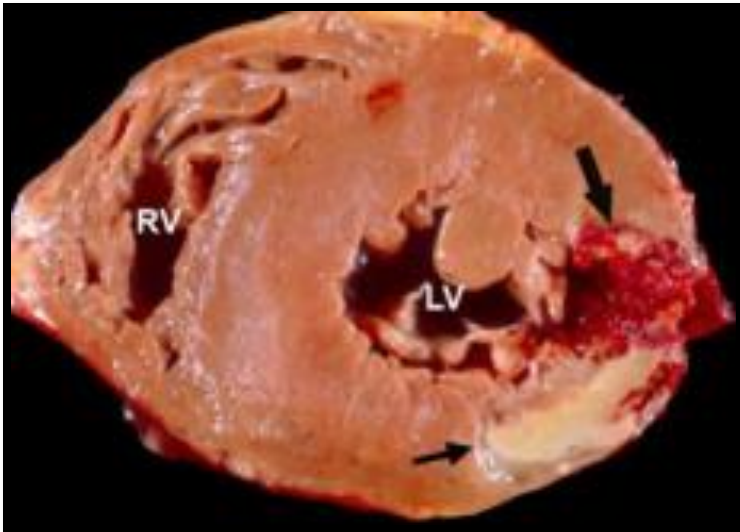
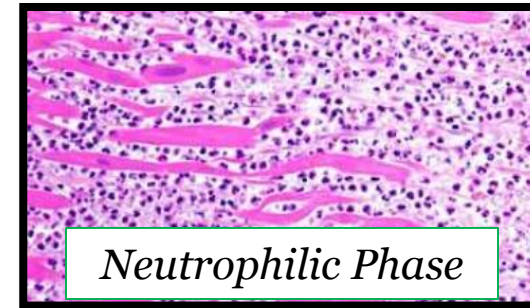
Complications

Microscopy

1-3 d



Fibrinous  
Pericarditis



Old woman found dead at home clutching  
bottle of SL NTG.  
Autopsy reveals **neutrophilic infiltrate**.  
When did she kick it?

- A. 1 hr ago (normal histopathology)
- B. **1 day ago**
- C. 1 week ago (macrophage phase)

*Derivative One*

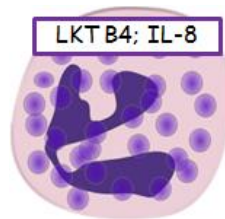
# Cardiac Pathology

Injury

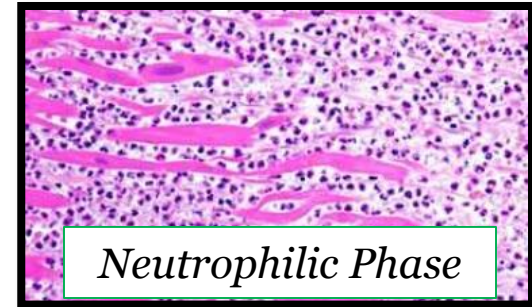
Complications

Microscopy

1-3 d

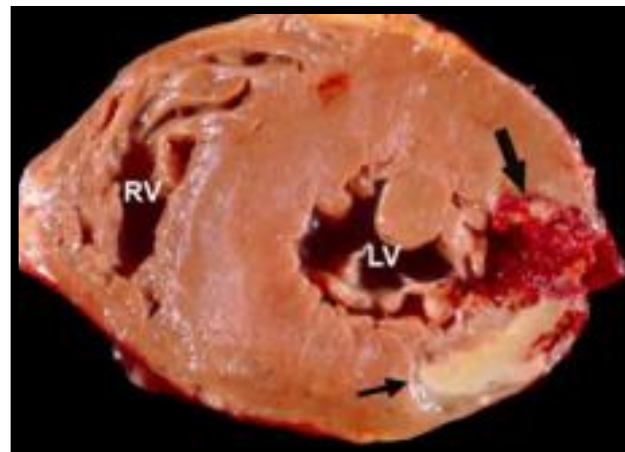


Fibrinous  
Pericarditis



Overlying the **necrotic segment of transmural infarction**  
(i.e. do not to confuse with autoimmune pericarditis seen later in course)

*Derivative Two*





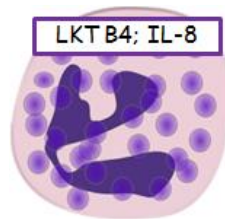
# Cardiac Pathology

Injury

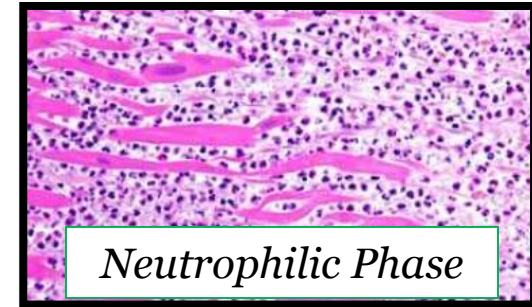
Complications

Microscopy

1-3 d

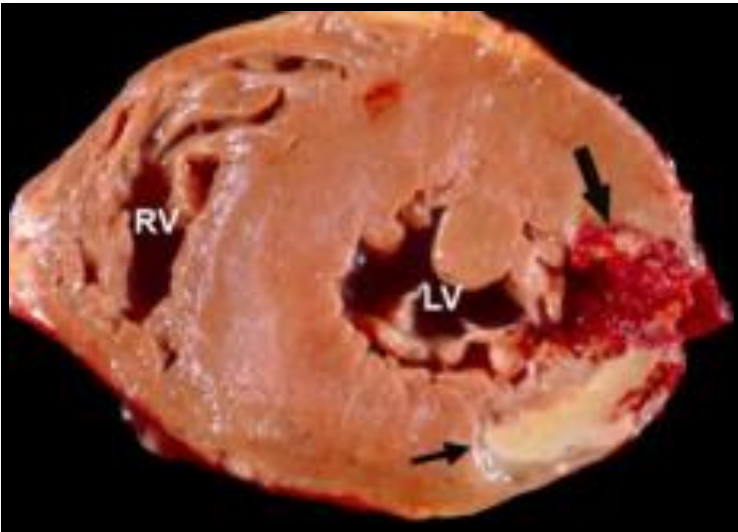


Fibrinous  
Pericarditis



Dude had STEMI 2 days ago. Now with recurrent chest pain. Refuses to lie down.  
Cause of pain?

- A. Extension of MI
- B. Pulmonary Embolism
- C. Tamponade
- D. Chordae tendinae rupture
- E. Coronary Vasospasm
- F. Serofibrinous Pericarditis
- G. Purulent Pericarditis
- H. Decompensated CHF



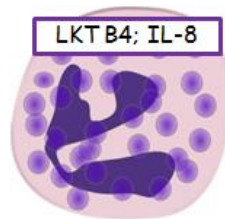
# Cardiac Pathology

Injury

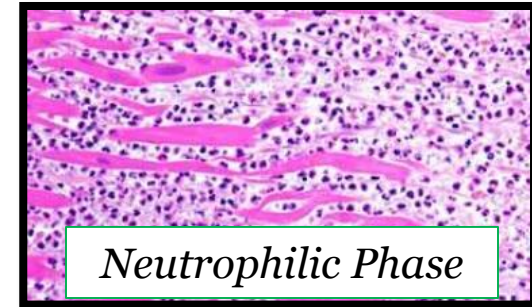
Complications

Microscopy

1-3 d



Fibrinous  
Pericarditis



Dude had STEMI 2 days ago.  
Now with recurrent chest pain. Refuses to lie down.  
Cause of pain?

- A. Extension of MI (need CK)
- B. Pulmonary Embolism
- C. Tamponade (day 5; need pulsus paradoxus)
- D. Chordae tendinae rupture (day 5; need murmur)
- E. Coronary Vasospasm
- F. Serofibrinous Pericarditis**
- G. Purulent Pericarditis (infectious, not post-MI)
- H. Decompensated CHF (need rales, S3)

## Cardiac Pathology

Injury

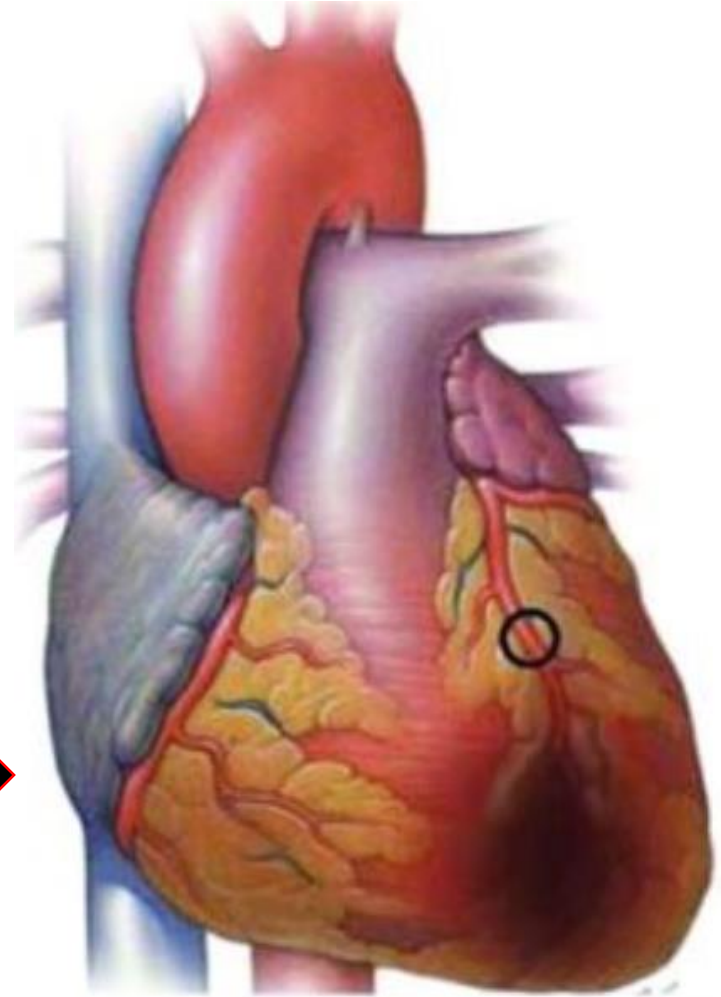
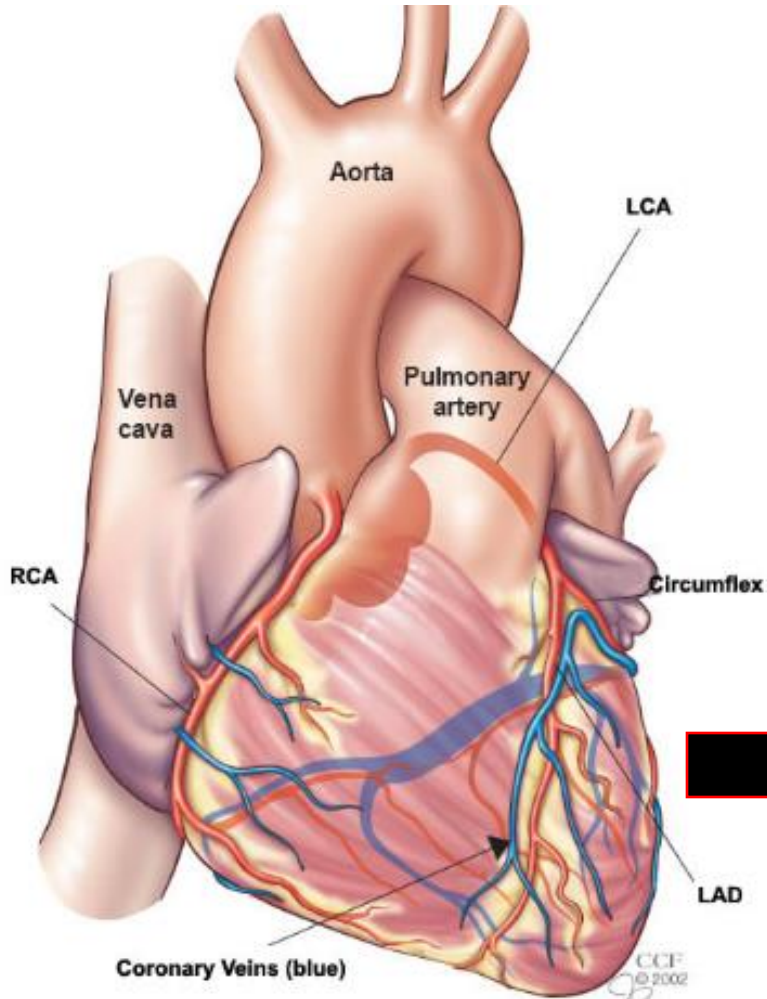
Complications

Microscopy

*Quick Associations* when *briefly* reviewing the wrong answers

Dude had STEMI 2 days ago.  
Now with recurrent chest pain. Refuses to lie down.  
Cause of pain?

- A. Extension of MI (need CK)
- B. Pulmonary Embolism
- C. Tamponade (day 5; need pulsus paradoxus)
- D. Chordae tendinae rupture (day 5; need murmur)
- E. Coronary Vasospasm
- F. Serofibrinous Pericarditis**
- G. Purulent Pericarditis (infectious, not post-MI)
- H. Decompensated CHF (need rales, S3)



120 seconds

20-30 mins

0-6 hours

1-3 days

3-7 days

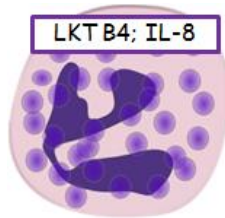
# Cardiac Pathology

Injury

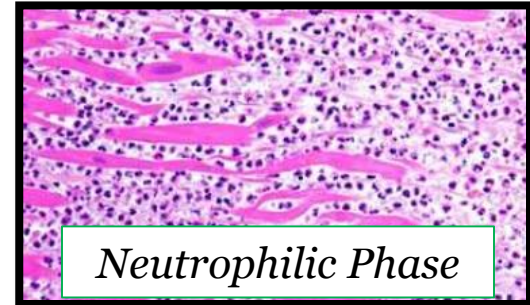
Complications

Microscopy

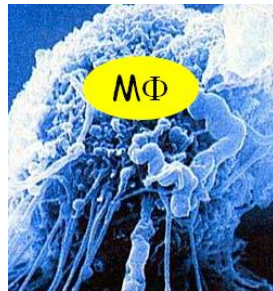
1-3 d



Fibrinous  
Pericarditis



3-7 d



Rupture:  
LV  
Papillary MM



*'...disintegration of dead myofibers...'*



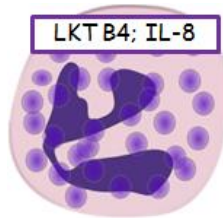
# Cardiac Pathology

Injury

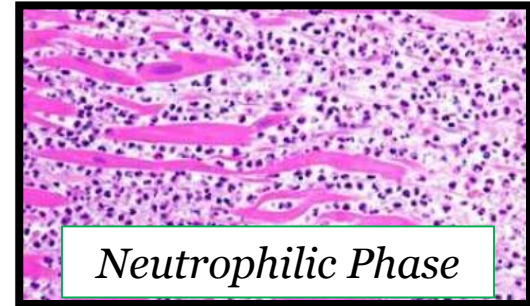
Complications

Microscopy

1-3 d



Fibrinous  
Pericarditis



Rupture:  
LV  
Papillary MM



*'...disintegration of dead myofibers...'*



# Cardiac Pathology

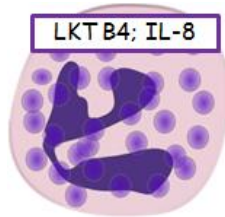
Injury

Complications

Microscopy

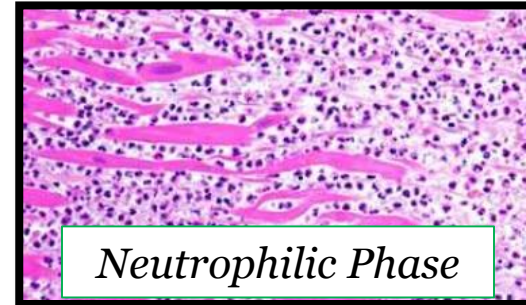
1-3 d

LKT B4; IL-8



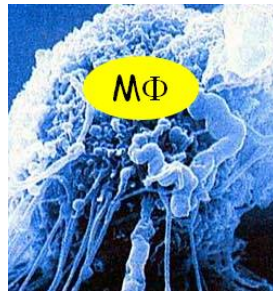
Fibrinous  
Pericarditis

*Neutrophilic Phase*



3-7 d

MΦ



Rupture:  
LV  
Papillary MM

*Macrophage Phase*



Dude with STEMI 5 days ago.

1. Now with hypotension/pulsus paradoxus (*diff dx of shock*).
2. Now with acute CHF and new 3/6 systolic murmur at apex



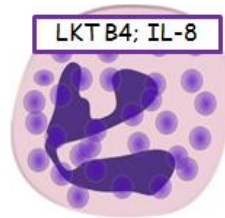
# Cardiac Pathology

Injury

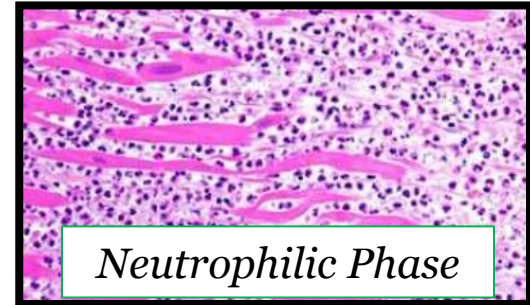
Complications

Microscopy

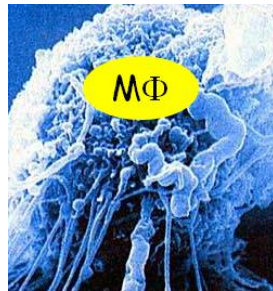
1-3 d



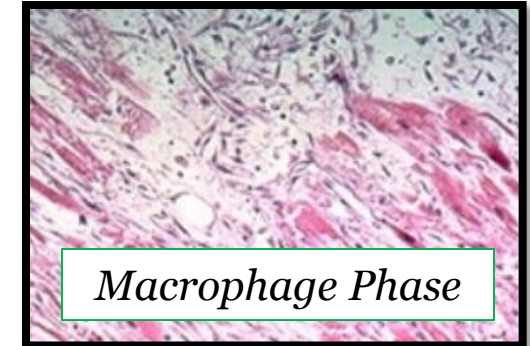
Fibrinous  
Pericarditis



3-7 d



Rupture:  
LV  
Papillary MM



Dude with STEMI 5 days ago.

1. Now with hypotension/pulsus paradoxus (*diff dx of shock*).
2. Now with acute CHF and new 3/6 systolic murmur at apex

Diagnosis?

Which cell most likely caused/contributed?





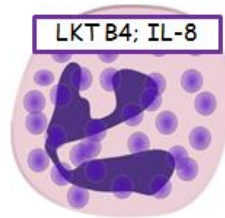
# Cardiac Pathology

Injury

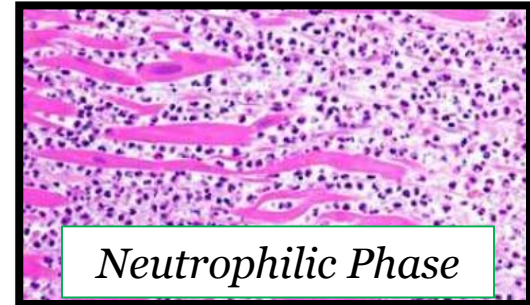
Complications

Microscopy

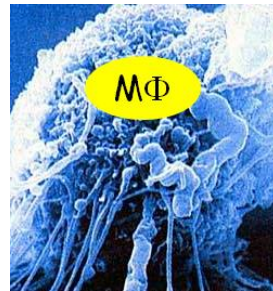
1-3 d



Fibrinous  
Pericarditis



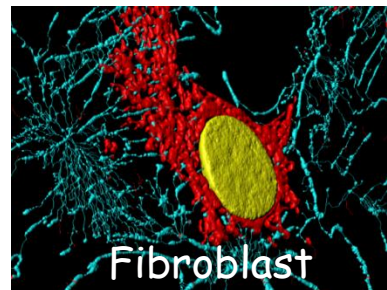
3-7 d



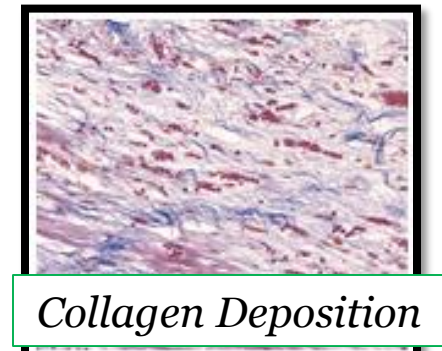
Rupture:  
LV  
Papillary MM



>30 d



Aneurysm  
Mural thrombus  
Dressler's



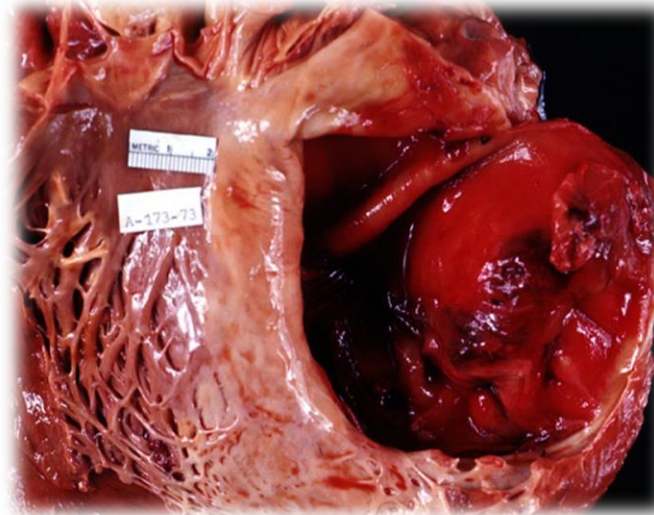
# Cardiac Pathology

Injury

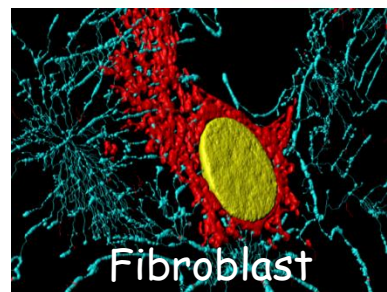
Complications

Microscopy

LV Aneurysm → Mural Thrombus  
...what's the end game of these questions?

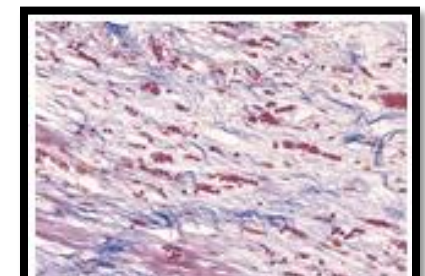


>30 d



Fibroblast

Aneurysm  
Mural thrombus  
Dressler's



Collagen Deposition

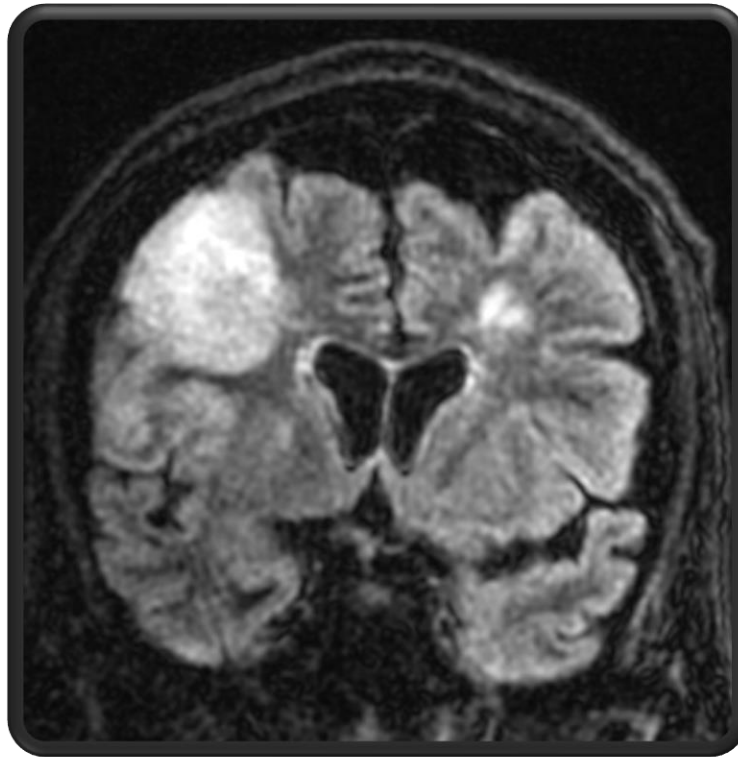
## Cardiac Pathology

Injury

Complications

Microscopy

LV Aneurysm → Mural Thrombus  
...what's the end game of these questions?



## Cardiac Pathology

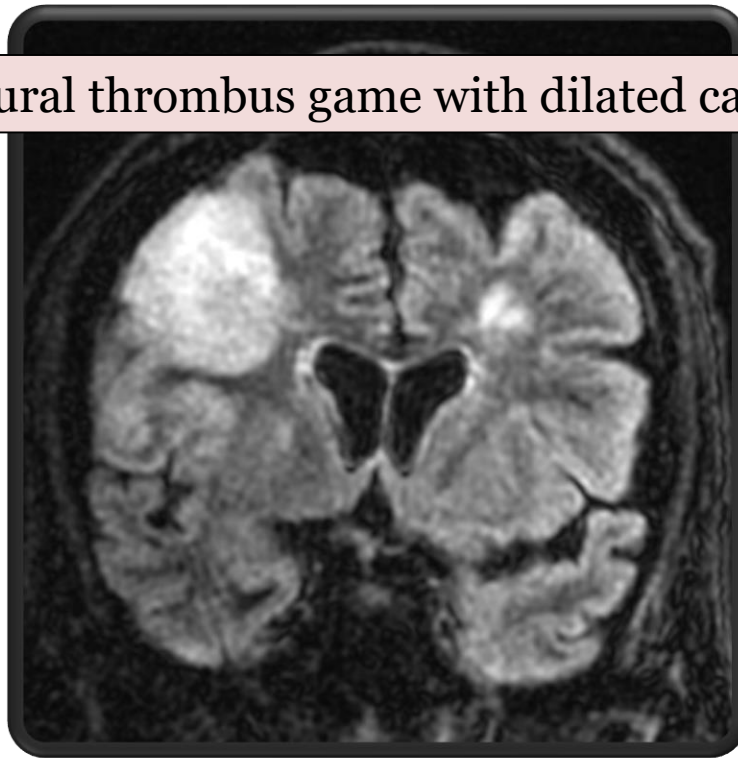
Injury

Complications

Microscopy

LV Aneurysm → Mural Thrombus  
...what's the end game of these questions?

They play the mural thrombus game with dilated cardiomyopathy.



# Cardiac Pathology

Injury

Complications

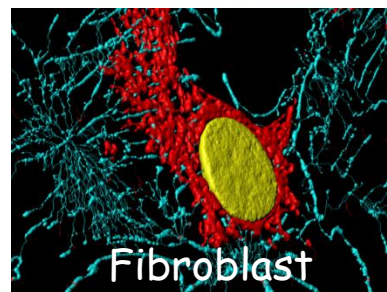
Microscopy

LV Aneurysm → Mural Thrombus

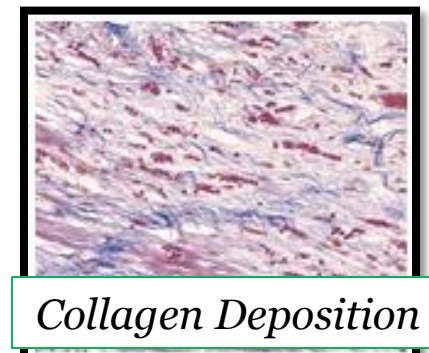
## Dressler's Syndrome: Autoimmune Pericarditis

- Pathology – serofibrinous
- Target tissue – released *myocardial antigens*
- Presentation - similar to acute pericarditis except timing *6-8 weeks*

>30 d



Aneurysm  
Mural thrombus  
Dressler's

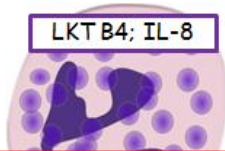




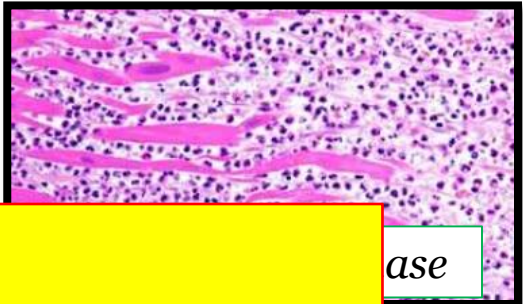
0-6h

Injury      Complications      Microscopy

1-3 d



Fibrinous  
Pericarditis

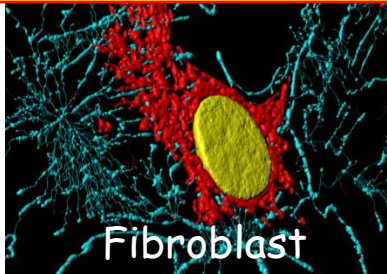


3-7 d

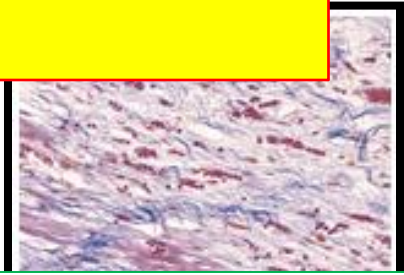
The material presented will get you out of a few jams...



>30 d

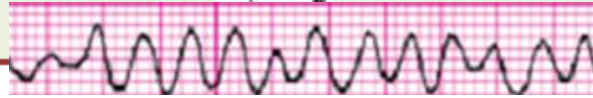


Aneurysm  
Mural thrombus  
Dressler's



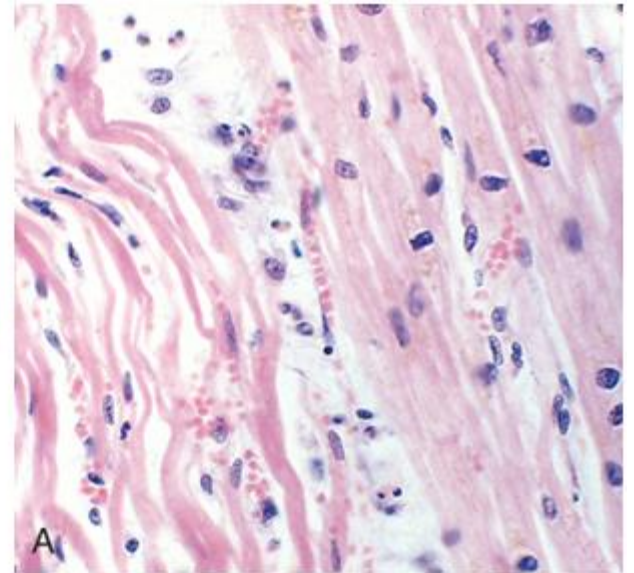
# Cardiac Pathology

0-6h

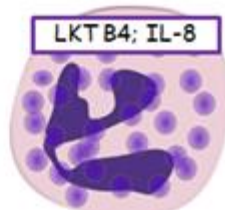


6-24 h

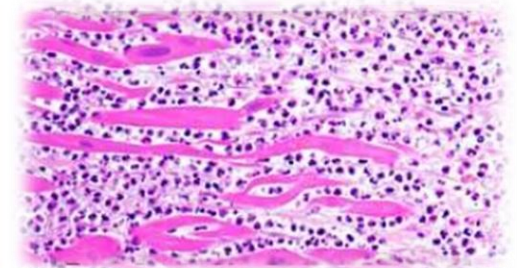
Wavy fibers, edema, punctate hemorrhage, contraction band and coagulative necrosis



1-3 d



Fibrinous Pericarditis



# Cardiac Pathology

Injury

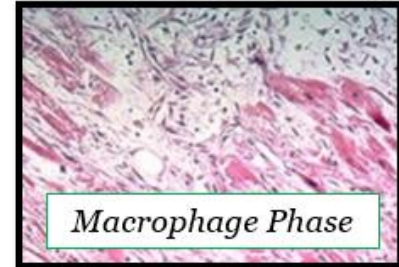
Complications

Microscopy

3-7 d

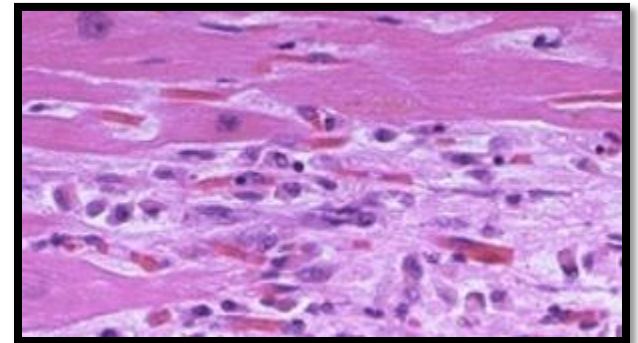


Rupture:  
LV  
Papillary MM



7-14 d

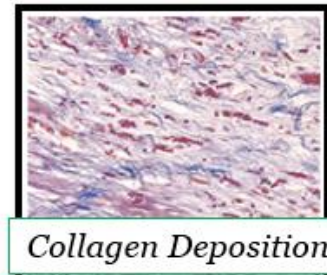
Granulation Tissue and  
Neovascularization  
(loose collagen and abundant capillaries)



>30 d



Aneurysm  
Mural thrombus  
Dressler's





120 seconds

20-30 mins

Loss of Contractility  
Onset of Irreversible Injury

0-6 hours

Fatal Arrhythmia  
No histopathology

> 30 days

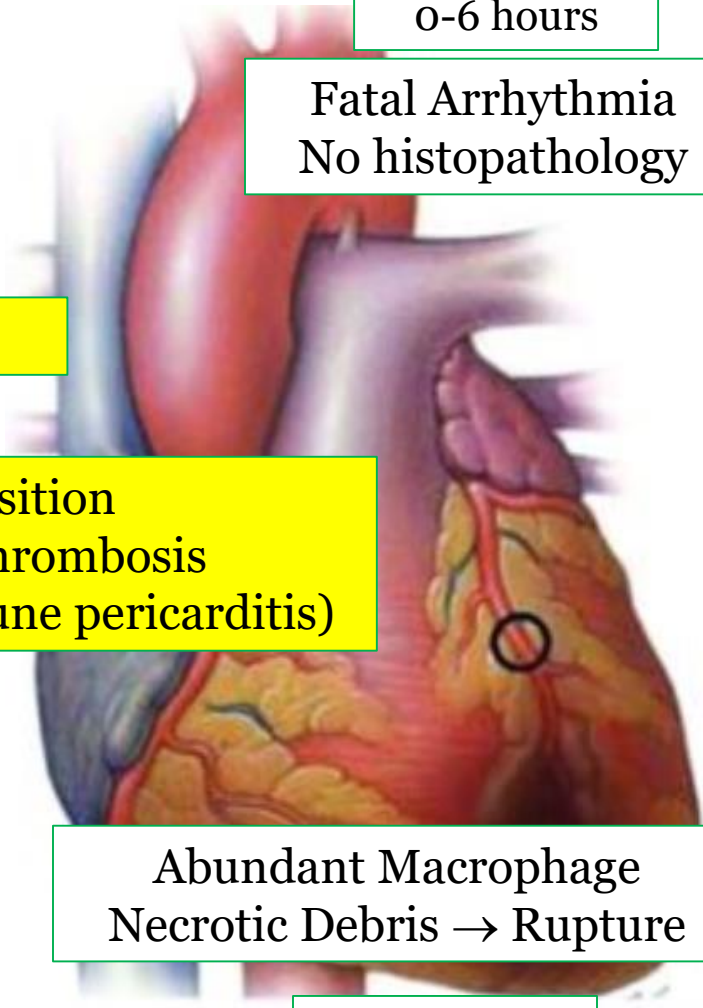
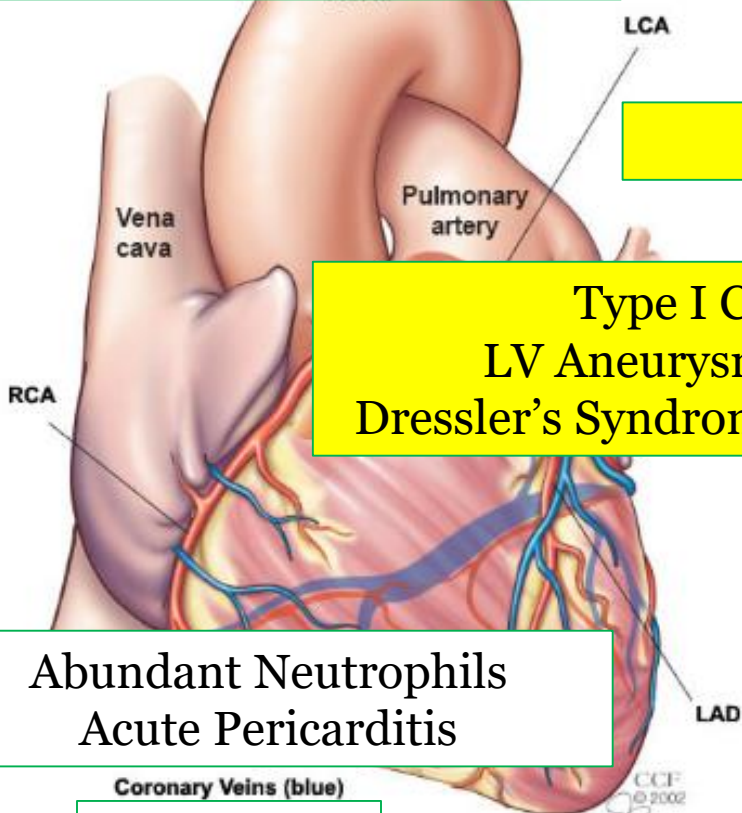
Type I Collagen Deposition  
LV Aneurysm → Mural Thrombosis  
Dressler's Syndrome (autoimmune pericarditis)

Abundant Neutrophils  
Acute Pericarditis

Abundant Macrophage  
Necrotic Debris → Rupture

1-3 days

3-7 days



Coronary Veins (blue)

CCF © 2002

120 seconds

20-30 mins

Loss of Contractility  
Onset of Irreversible Injury

6-24 hours

Wavy fibers, edema, punctate hemorrhage, contraction bands and coagulative necrosis

Abundant Neutrophils  
Acute Pericarditis

1-3 days

0-6 hours

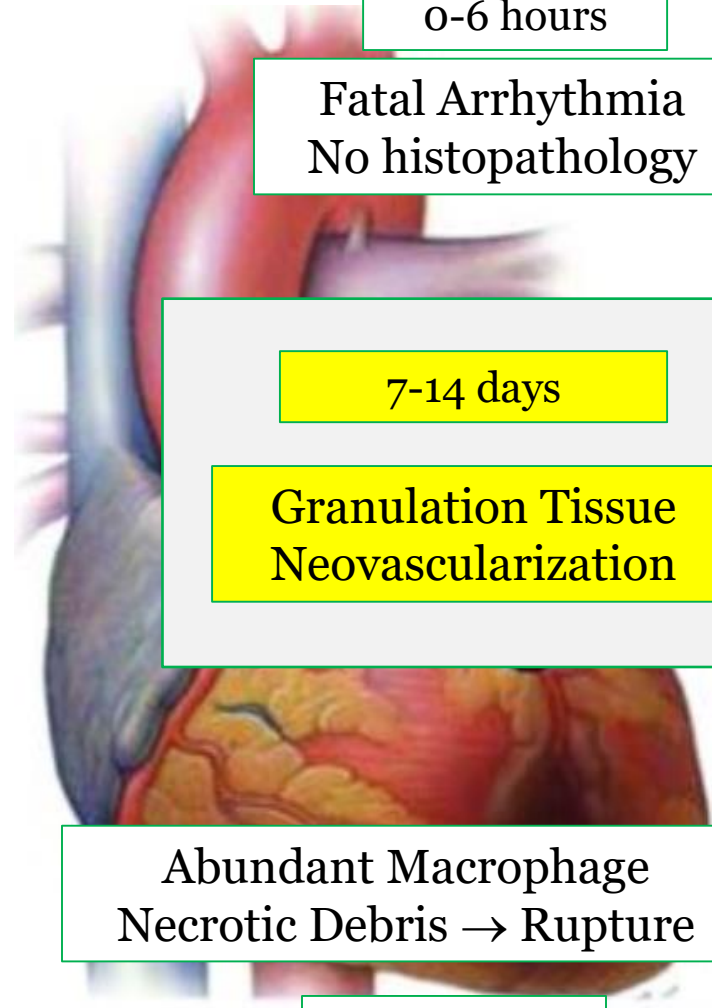
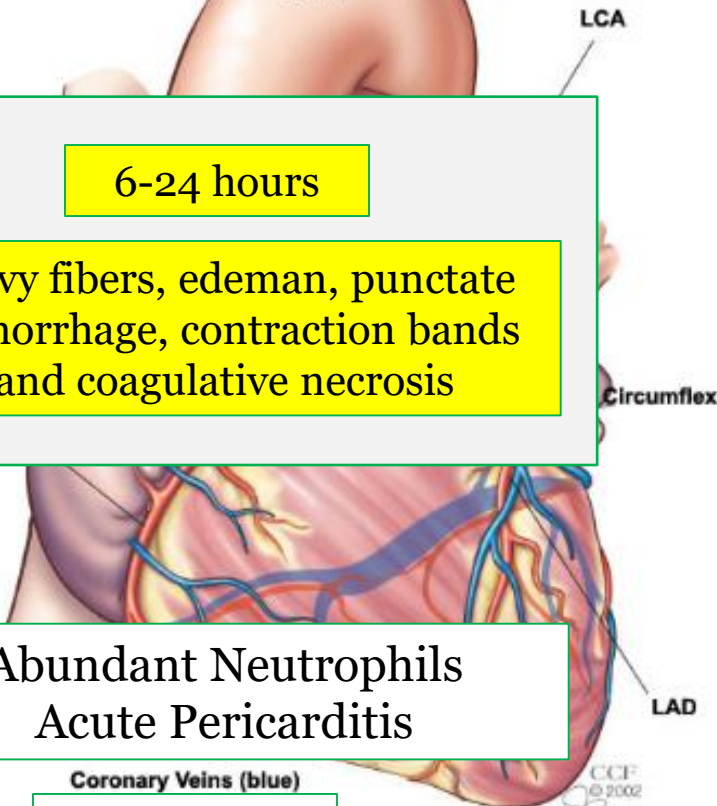
Fatal Arrhythmia  
No histopathology

7-14 days

Granulation Tissue  
Neovascularization

Abundant Macrophage  
Necrotic Debris → Rupture

3-7 days



# Myocardial Infarction and Cardiac Pathology for USMLE Step One



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*E-mail: Howard@12daysinmarch.com*