

# EVALUATION OF CARDIOVASCULAR HEALTH ENDPONTS FOLLOWING PM EXPOSURE

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HEALTH EFFECTS INSTITUTE ACES  
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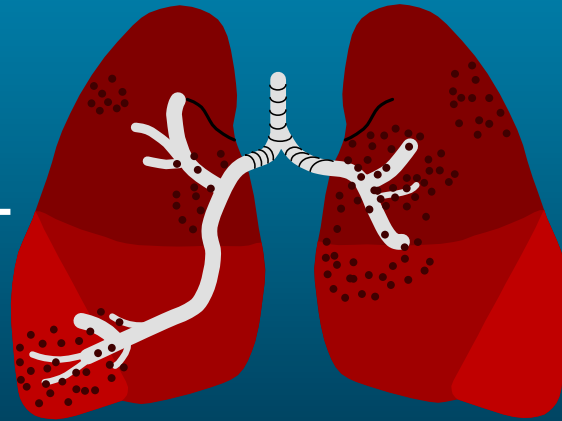
# Potential Effects of PM the Pulmonary System

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## Mechanisms of PM Pulmonary Effects

Lung Injury

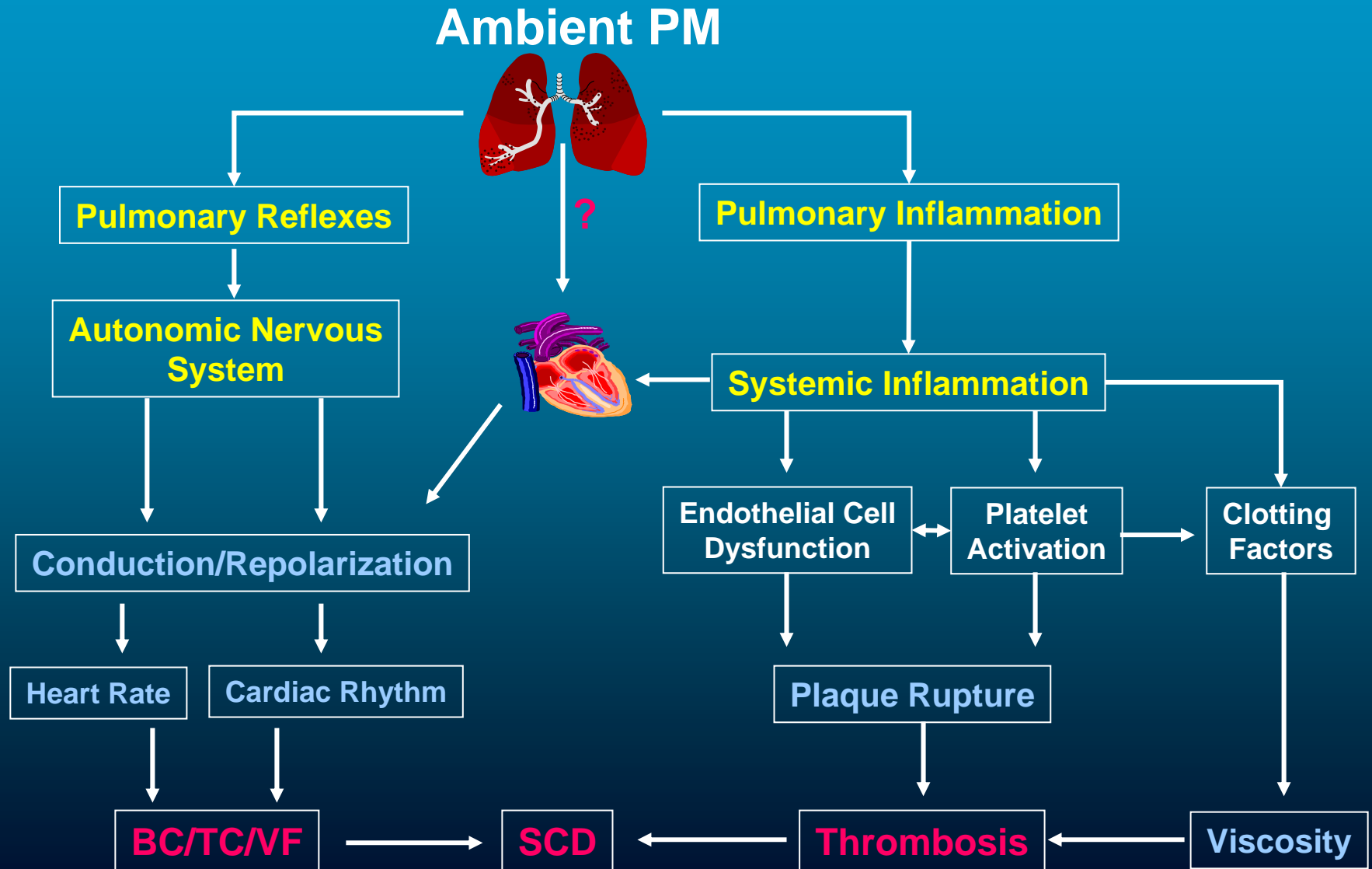
Altered Lung Function

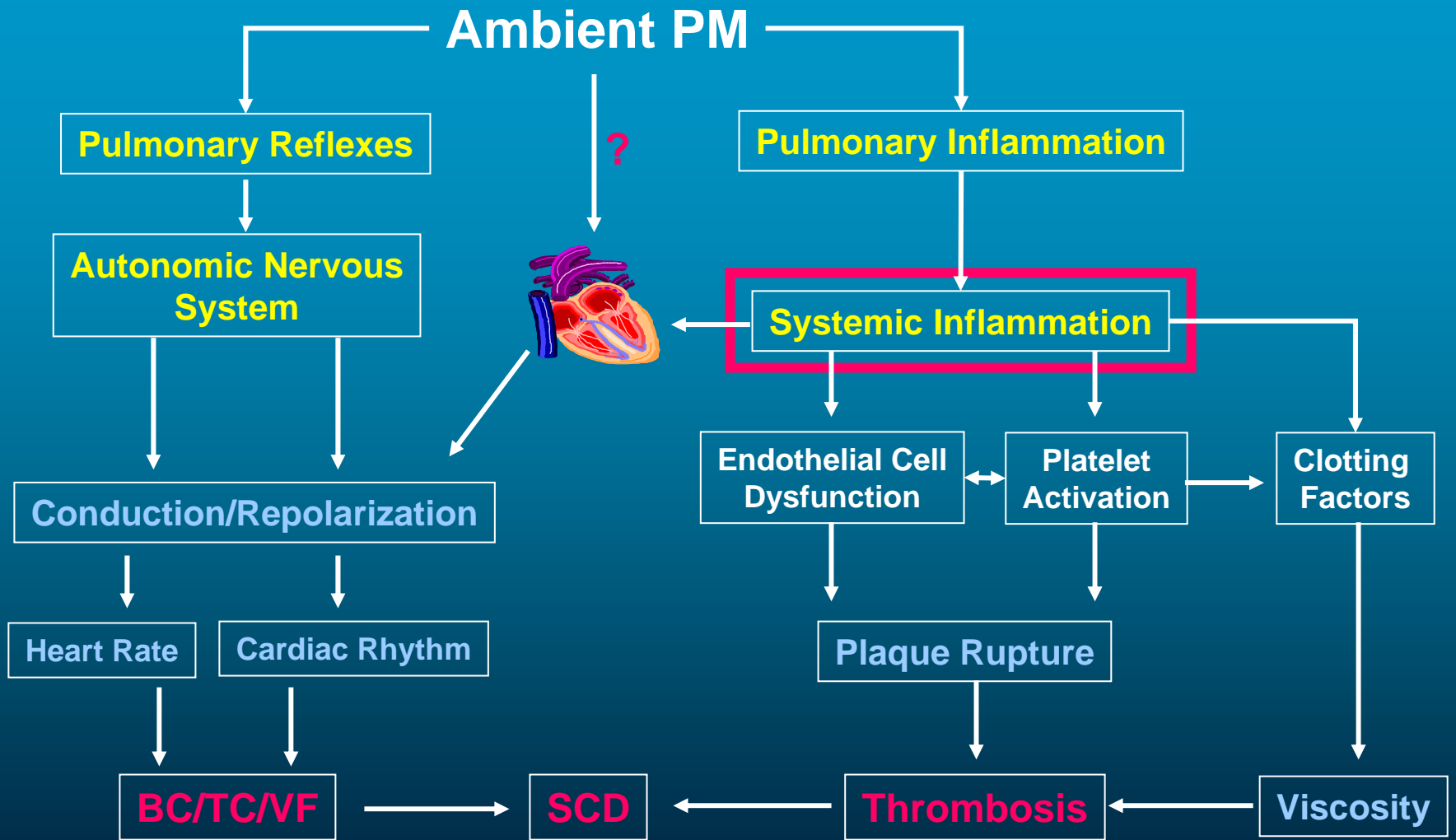


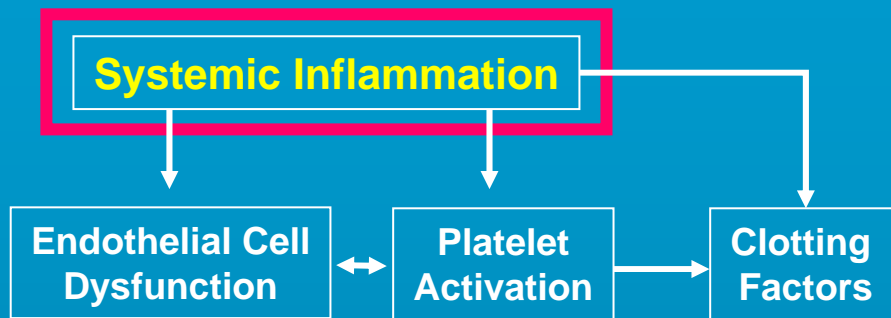
Exacerbation of  
Pulmonary Disease

Alter Pulmonary  
Immune Defenses

# Potential Effects of PM on the Cardiovascular System







**Seaton et al. (1999)**

**Elevation in CRP associated with increase in PM; decrease in red blood cells (Aberdeen study)**

**Peters et al. (2000)**

**Elevation in CRP associated with increase in PM (MONICA study)**

**Tan et al. (2000)**

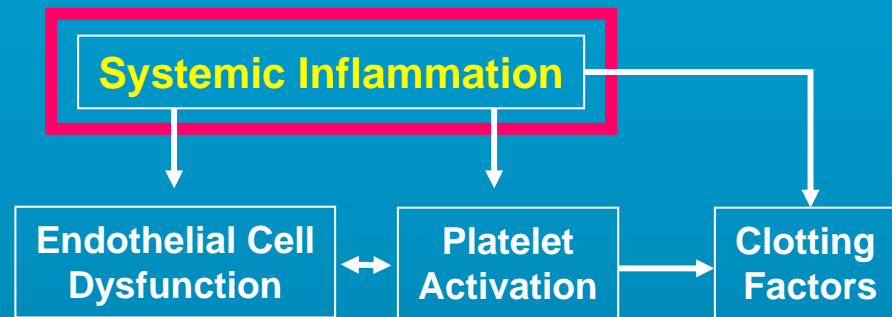
**Increased PMN precursor cells in humans exposed during Southeast Asian smoke-haze episode**

**Devlin et al. (2003)**

**Decrease in lymphocytes in elderly humans exposed to CAPS**

**Riediker et al. (2003)**

**Elevated CRP associated with exposure to PM enriched in particles derived from mobile sources**



**Gordon et al. (1998)**

**Increase in peripheral blood PMNs, decrease in lymphocytes in rats exposed to CAPS**

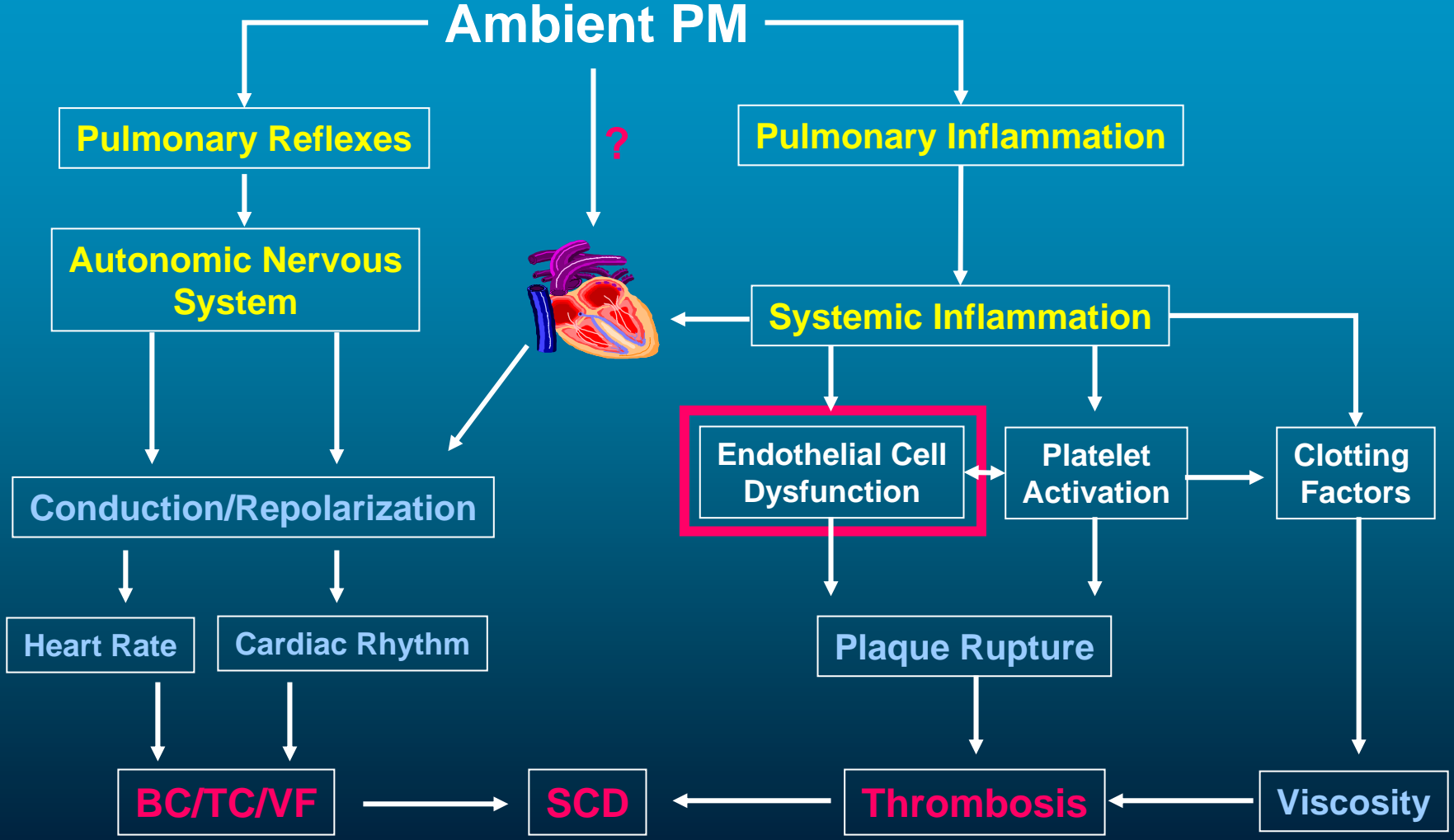
**Van Eeden et al. (2001)**

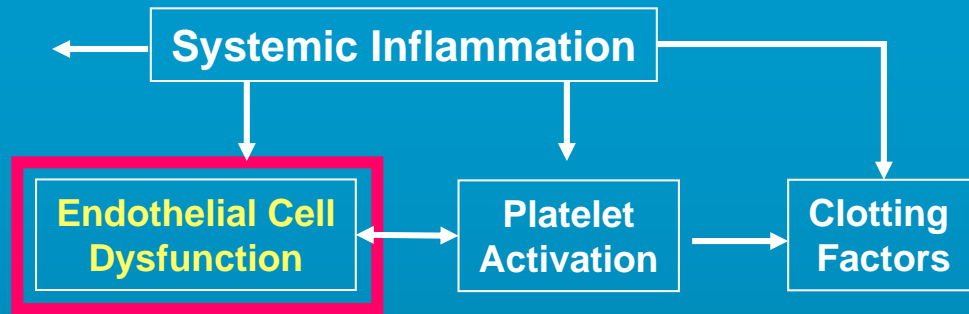
**Repeated exposure of rabbits to PM stimulates the bone marrow to increase the production of PMN in the marrow and accelerate the release of more immature PMN into the circulation**

**Kodavanti et al. (2002)**

**Decrease in plasma lymphocytes in rats exposed to ROFA**

# Ambient PM





Bouthillier et al. (1997)

Plasma endothelin increased in animals exposed to Ottawa PM

Vincent et al.

Plasma endothelin increased in humans and animals exposed to CAPS and O<sub>3</sub>

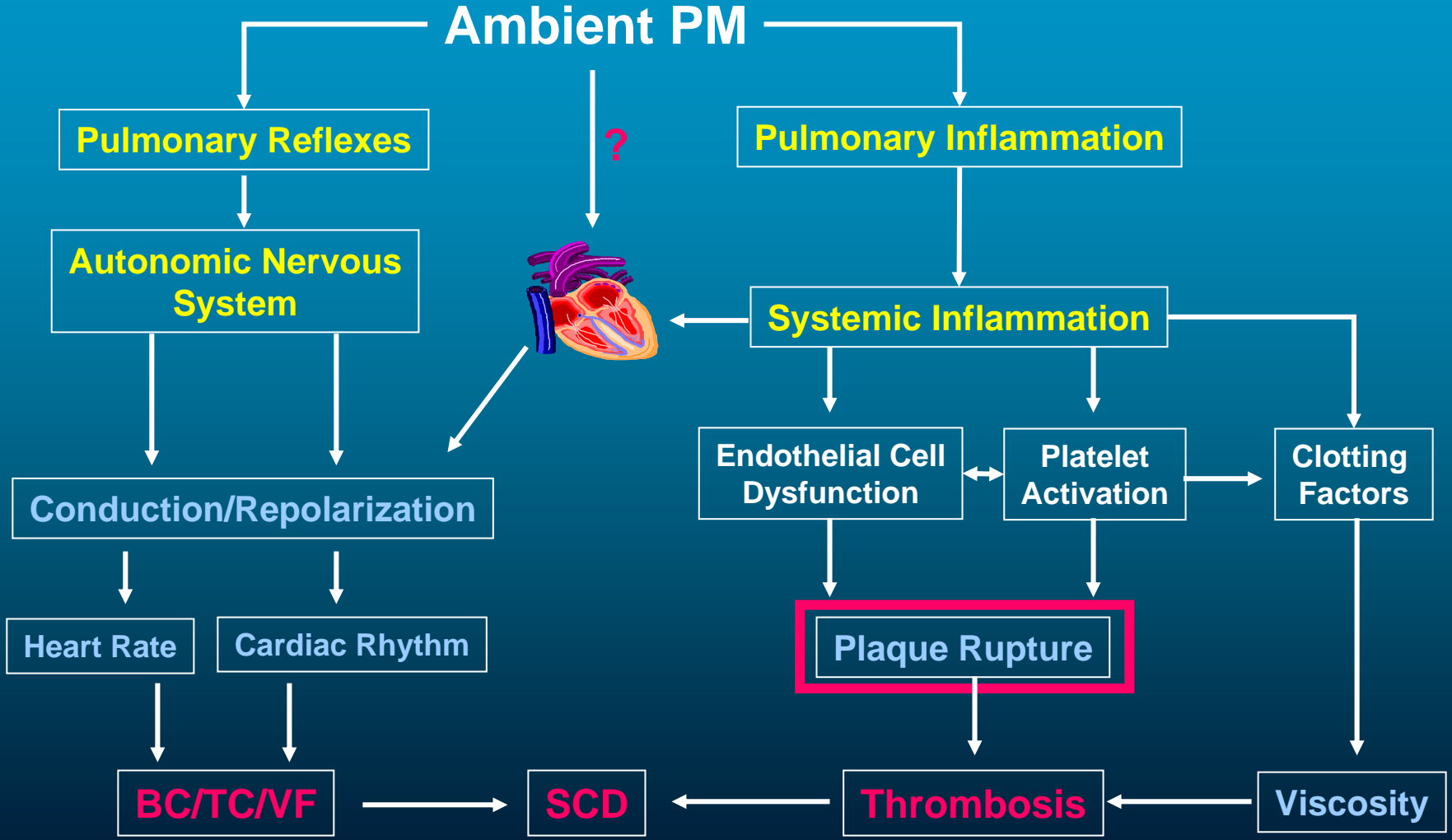
Brooks et al. (2001)

Exposure of humans to CAPS and O<sub>3</sub> alters arterial vasoconstriction

Johnson et al. (2002)

Exposure of pigs to oil fly ash causes increased pulmonary artery pressure

# Ambient PM



Pulmonary Reflexes

Autonomic Nervous System

Conduction/Repolarization

Heart Rate

Cardiac Rhythm

BC/TC/VF

SCD

Pulmonary Inflammation

Systemic Inflammation

Endothelial Cell Dysfunction

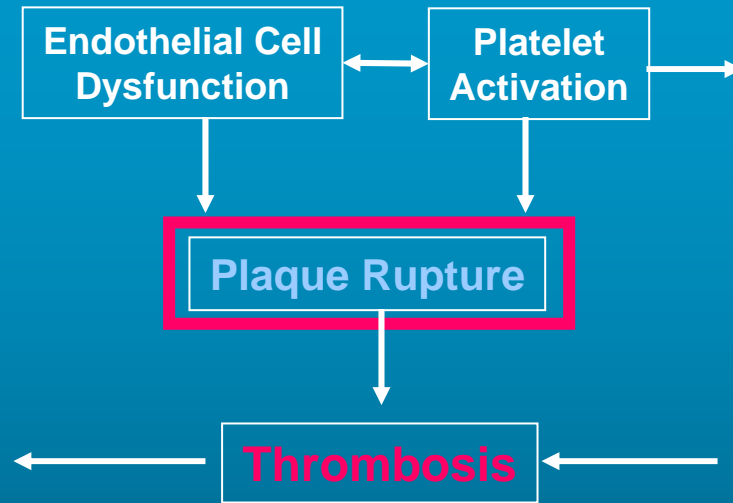
Platelet Activation

Clotting Factors

Plaque Rupture

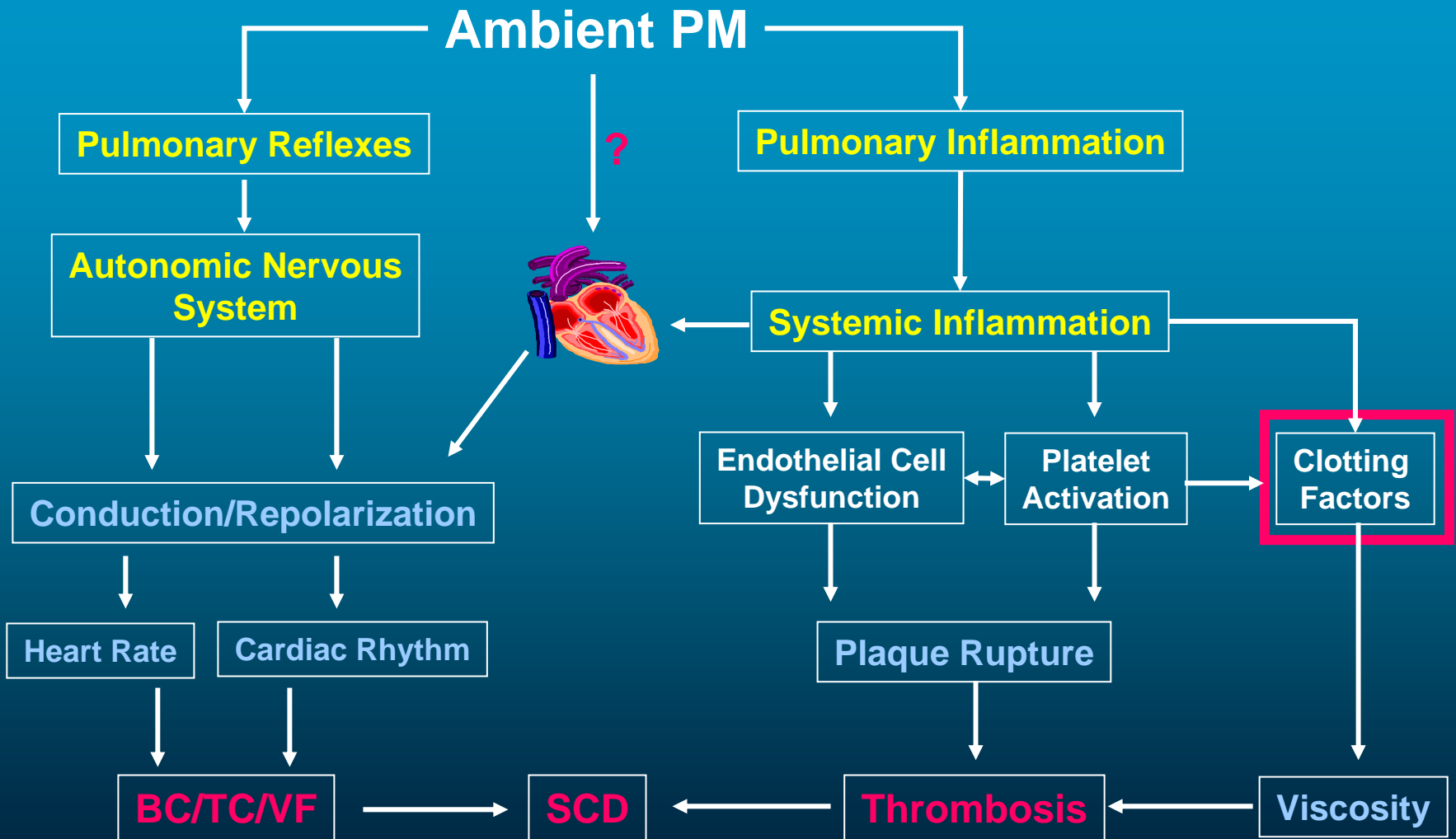
Thrombosis

Viscosity



Suwa et al. (2002)

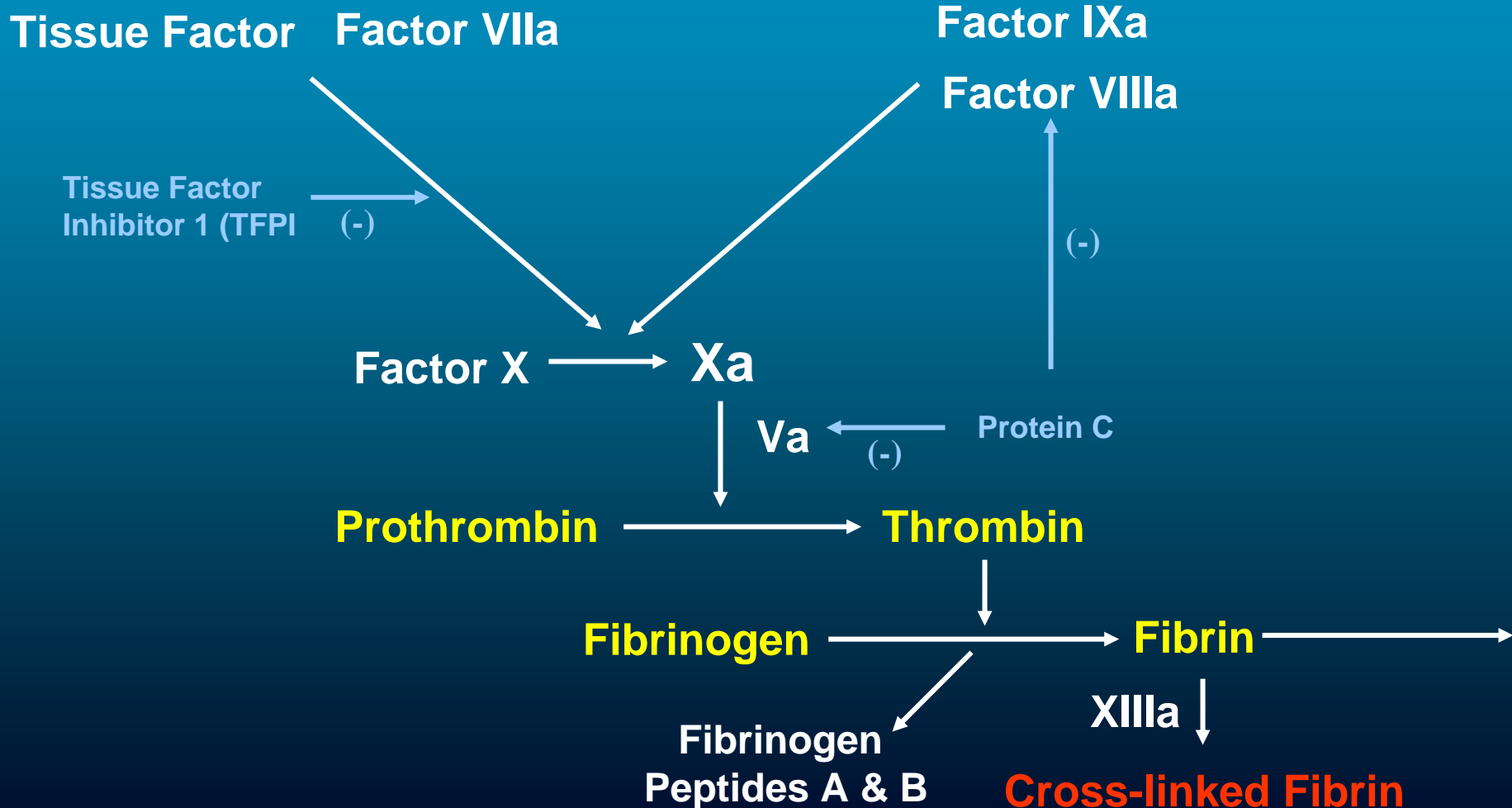
Exposure to PM collected from Ottawa caused a progression of atherosclerotic lesions towards a more advanced phenotype in hyperlipidemic rabbits.



# Coagulation Pathways

## Extrinsic

## Intrinsic





**Systemic Inflammation**

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graph TD; A[Systemic Inflammation] --> B[Clotting Factors]; B --> C[Viscosity];
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Seaton et al. (1999)

Aberdeen PM exposure associated with increased plasma fibrinogen, Factor VII

Prescott et al. (2001)

Edinburgh PM exposure associated with increased plasma fibrinogen

Schwartz (2001)

Association between plasma fibrinogen and PM exposure in NHANES III cohort

Gardener et al. (2000), Kodavanti et al. (2002)

Plasma fibrinogen increased in rats exposed to ROFA

Ghio et al. (2001)

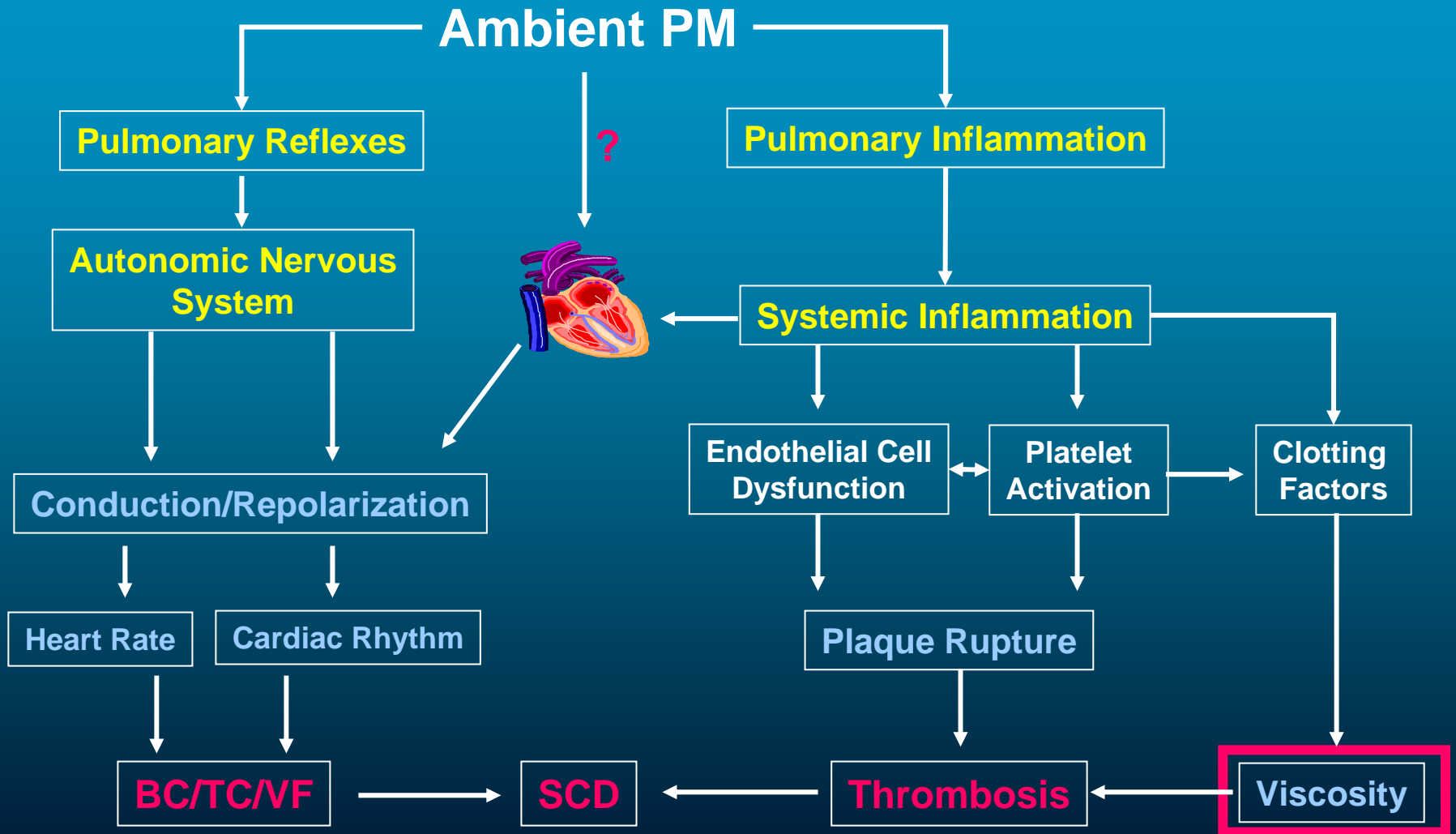
Plasma fibrinogen increased in healthy young humans exposed to CAPS

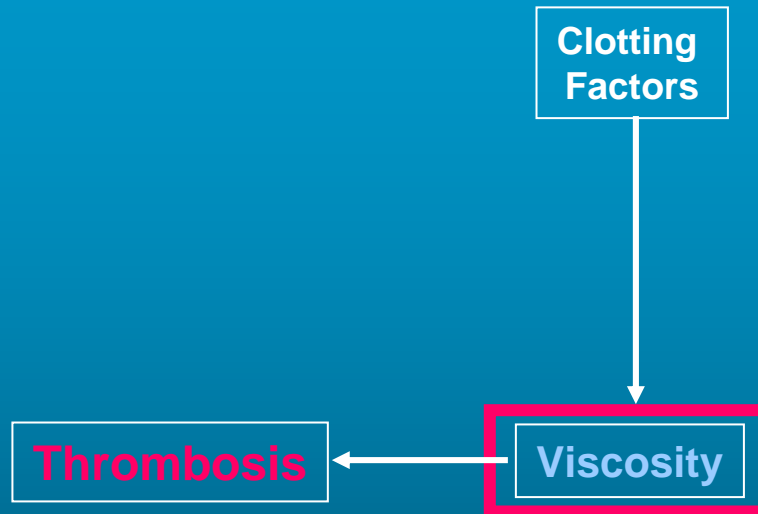
Devlin et al. (2003)

Increase in several coagulation factors in elderly humans exposed to CAPS

**Clotting Factors**

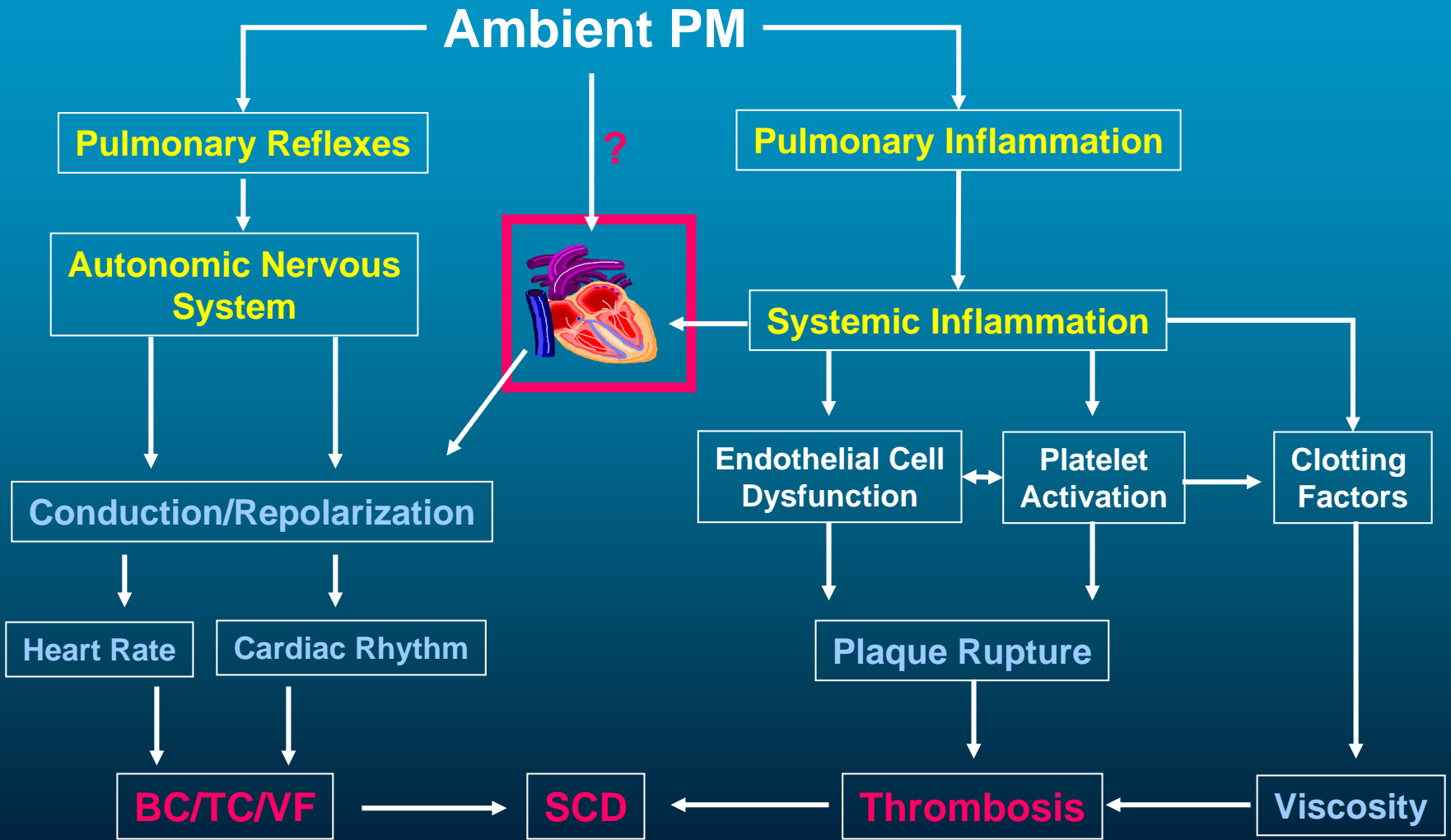
**Viscosity**



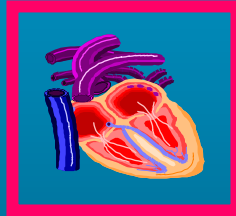


Peters et al. (1997)

Elevation in blood viscosity associated with increase in PM (MONICA study)



## Ambient PM



Killingsworth et al. (1997)

Increased MIP-2 in hearts of monocrotaline treated rats exposed to ROFA

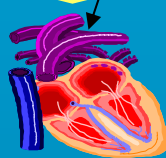
Kodavanti et al. (2000)

Cardiac myopathy and increased cytokine expression in left ventricle of rats exposed to ROFA

Calderon-Garciduenas et al. (2001)

Histopathology changes in hearts of dogs living in Mexico City compared with control areas

**PM or PM Components, Pulmonary Reflexes, Pulmonary or Systemic Inflammation**



**Sodium Channels, Calcium Channels, Gap Junctions**

**Potassium Channels**

**Automaticity**

**Conduction**

**Repolarization**

Heart rate  
HRV

QRS morphology  
& duration

QT intervals & dispersion  
ST segment changes  
T-wave alternans

PM or PM Components →  
Disease →

**Arrhythmogenic  
Substrate**

← Ischemia/Reperfusion  
← ANS  
← Drugs

**Sinus Node**

**Atrium**

**AV Node**

**Conduction System**

**Ventricle**

Sinus BC

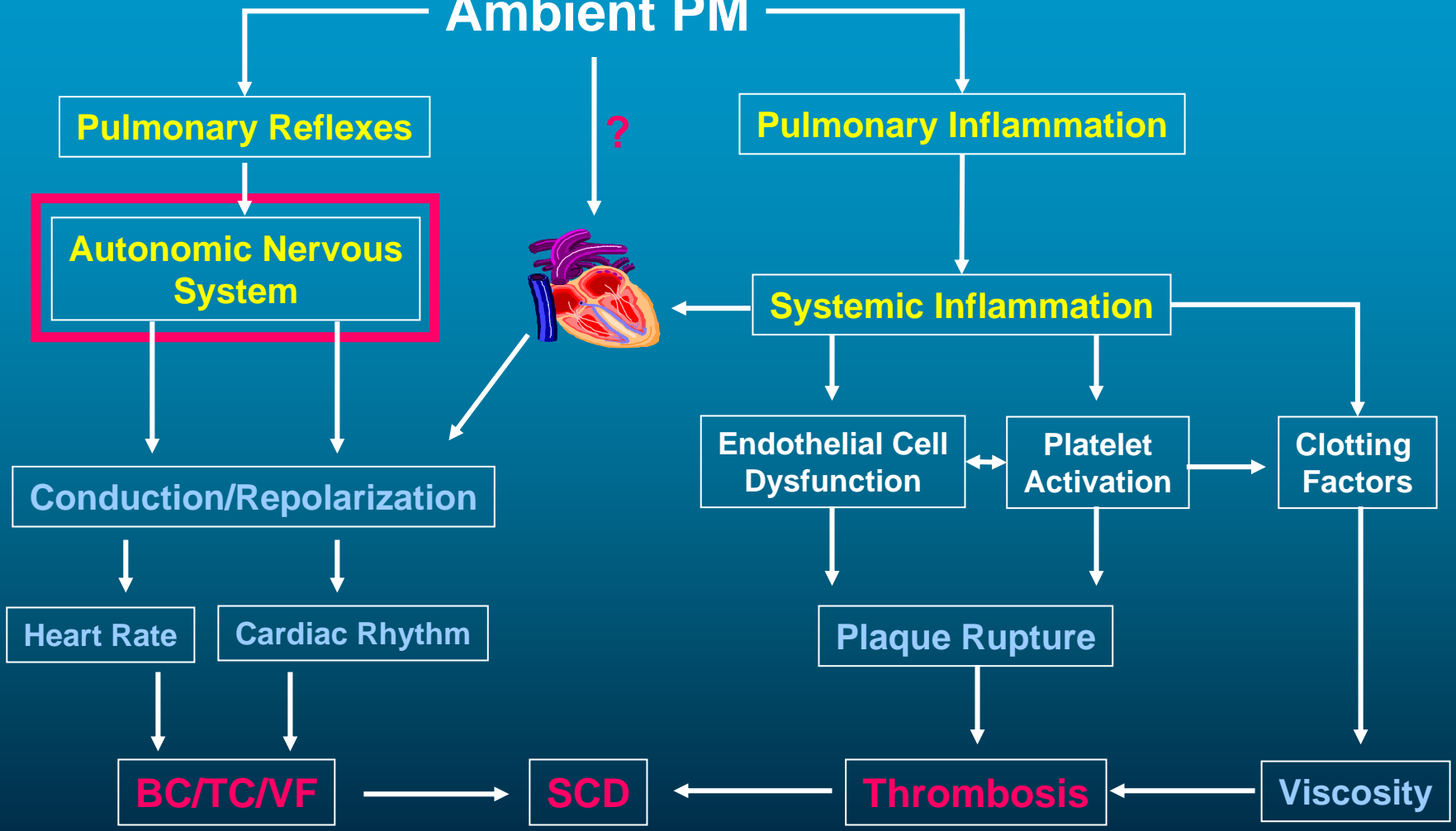
PACs, AT, AF

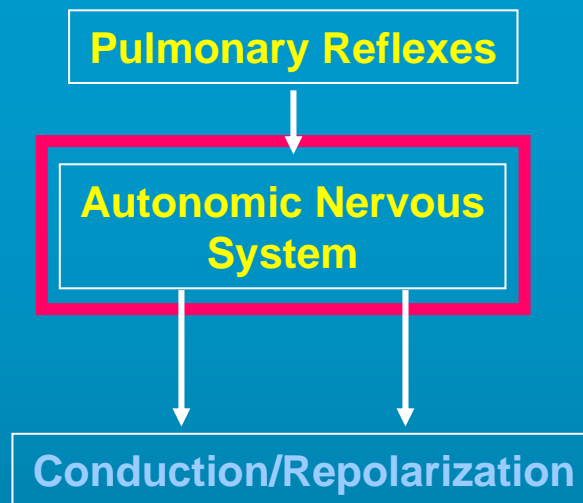
AV Block

Bundle Branch Block

PVCs, VT, VF

# Ambient PM





Liao et al. (1999)

Association between PM and decreased HRV in elderly residents of a Baltimore retirement home

Pope et al. (1999)

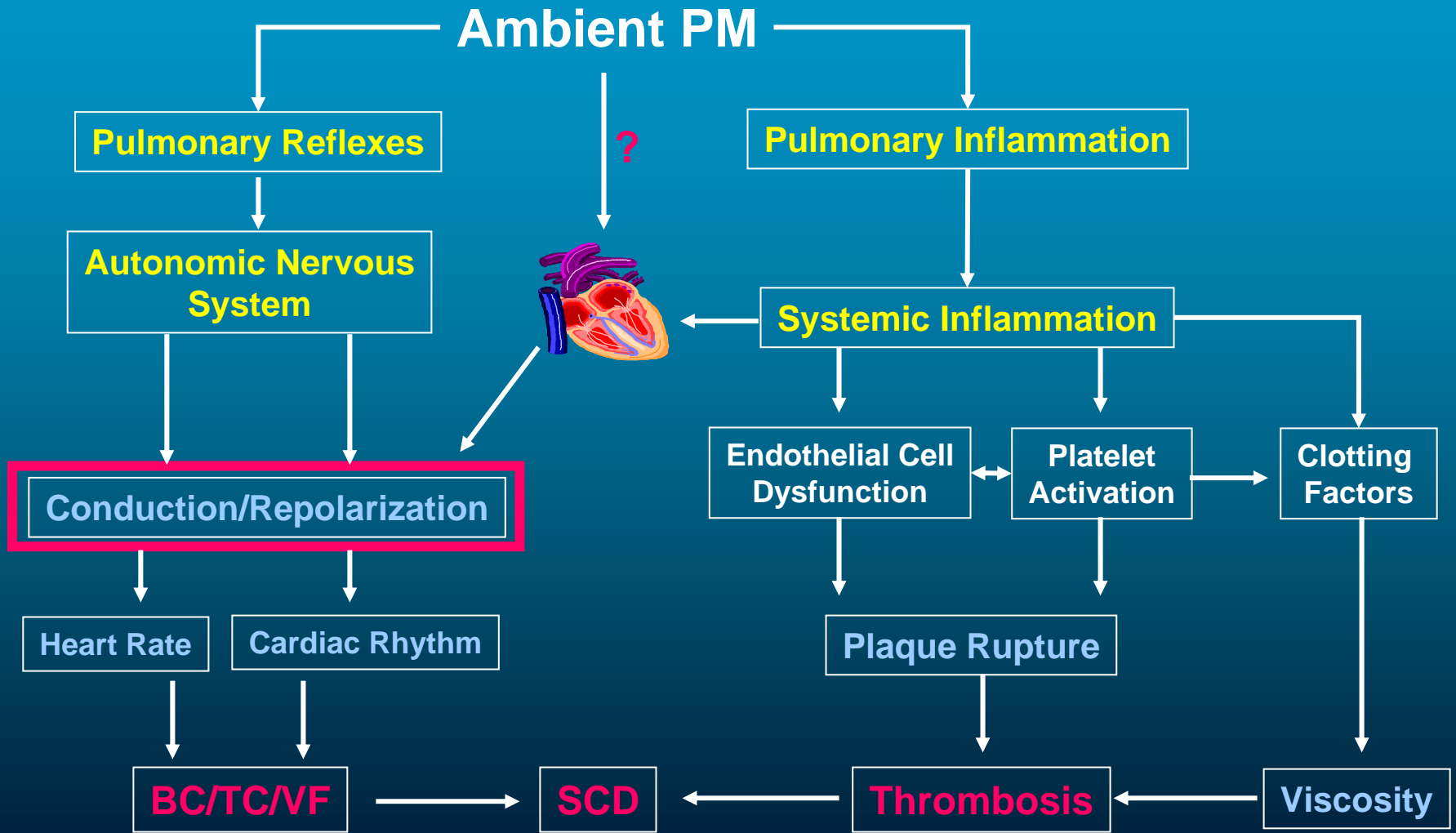
Association between PM and decreased HRV in elderly people with cardiopulmonary disease

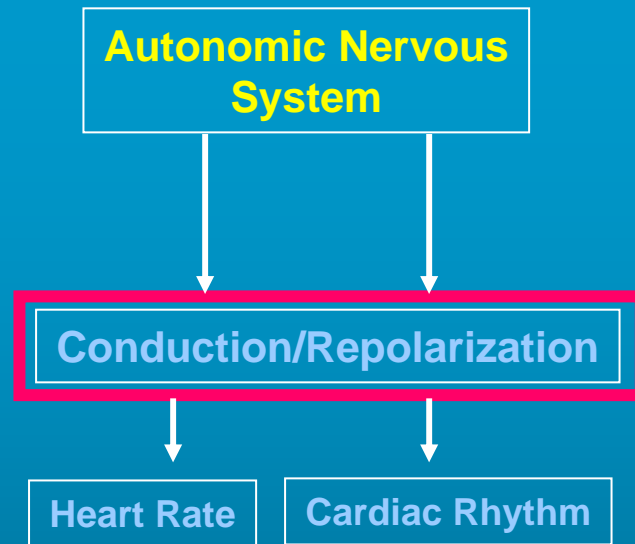
Gold et al. (2000)

Association between PM and decreased HRV elderly residents of a Boston residential community

Devlin et al.(2003)

Elderly people exposed to CAPS have decreased HRV





Costa et al. (1997)

S-T segment inversions in monocrotaline treated rats exposed to ROFA

Godleski et al. (2000)

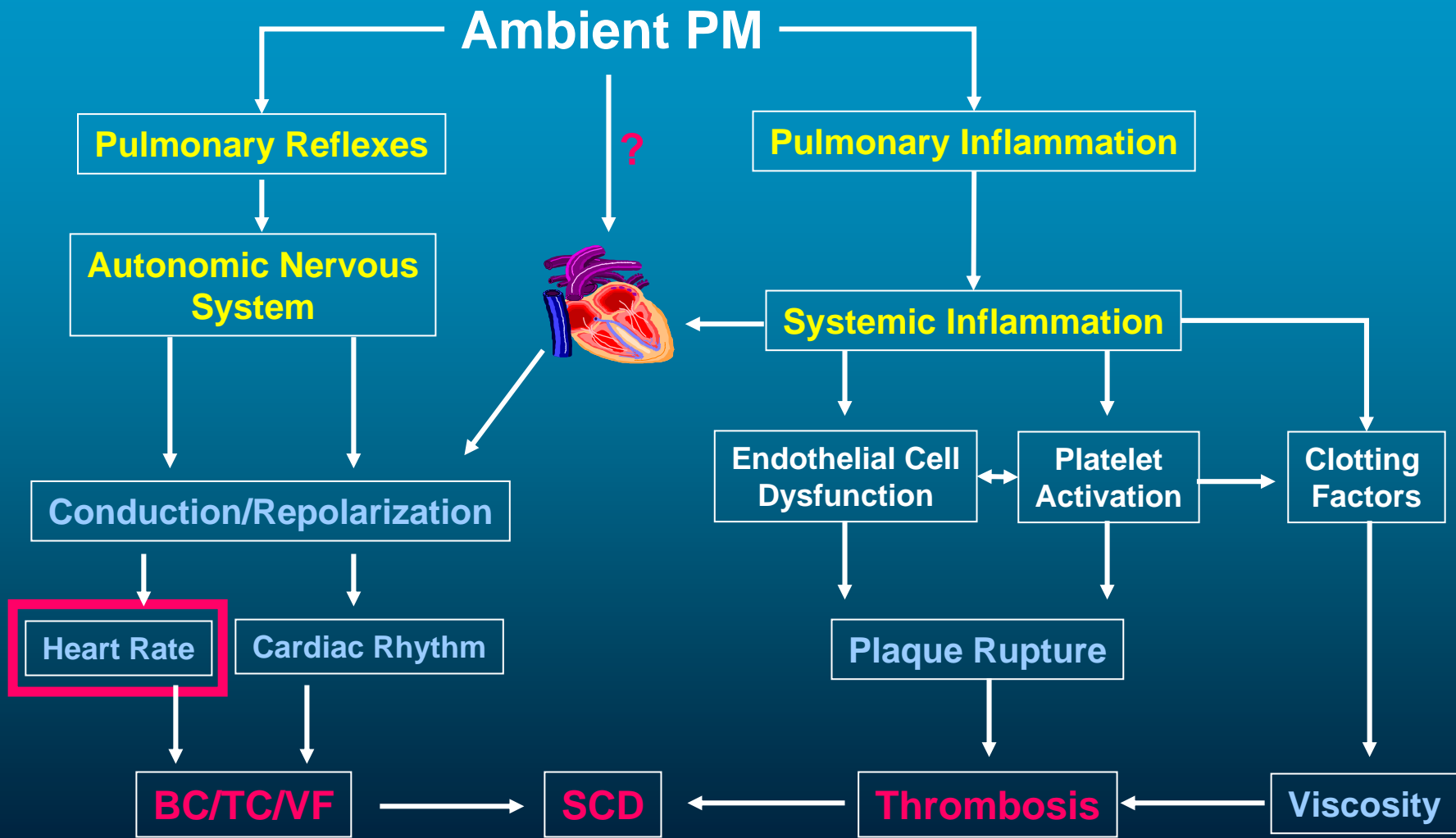
Increased T wave alternans in dogs exposed to CAPS; increased S-T segment elevation in dogs with coronary occlusion exposed to CAPS

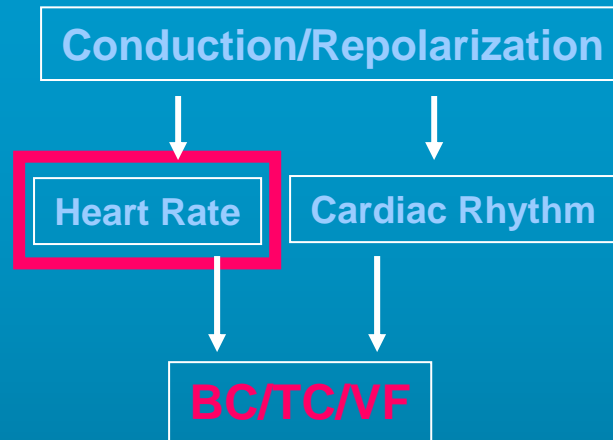
Kodavanti et al. (2000)

Exacerbated S-T segment changes in rats exposed to ROFA

Johnson et al.(2002)

Decreased activation recovery intervals in pigs exposed to ROFA





Pope et al. (1999)

HR positively associated with exposure to PM

Peters et al. (1999)

HR positively associated with exposure to PM

Gold et al. (2000)

HR negatively associated with exposure to PM

Gordon et al. (1998)

HR increase in rats exposed to CAPS

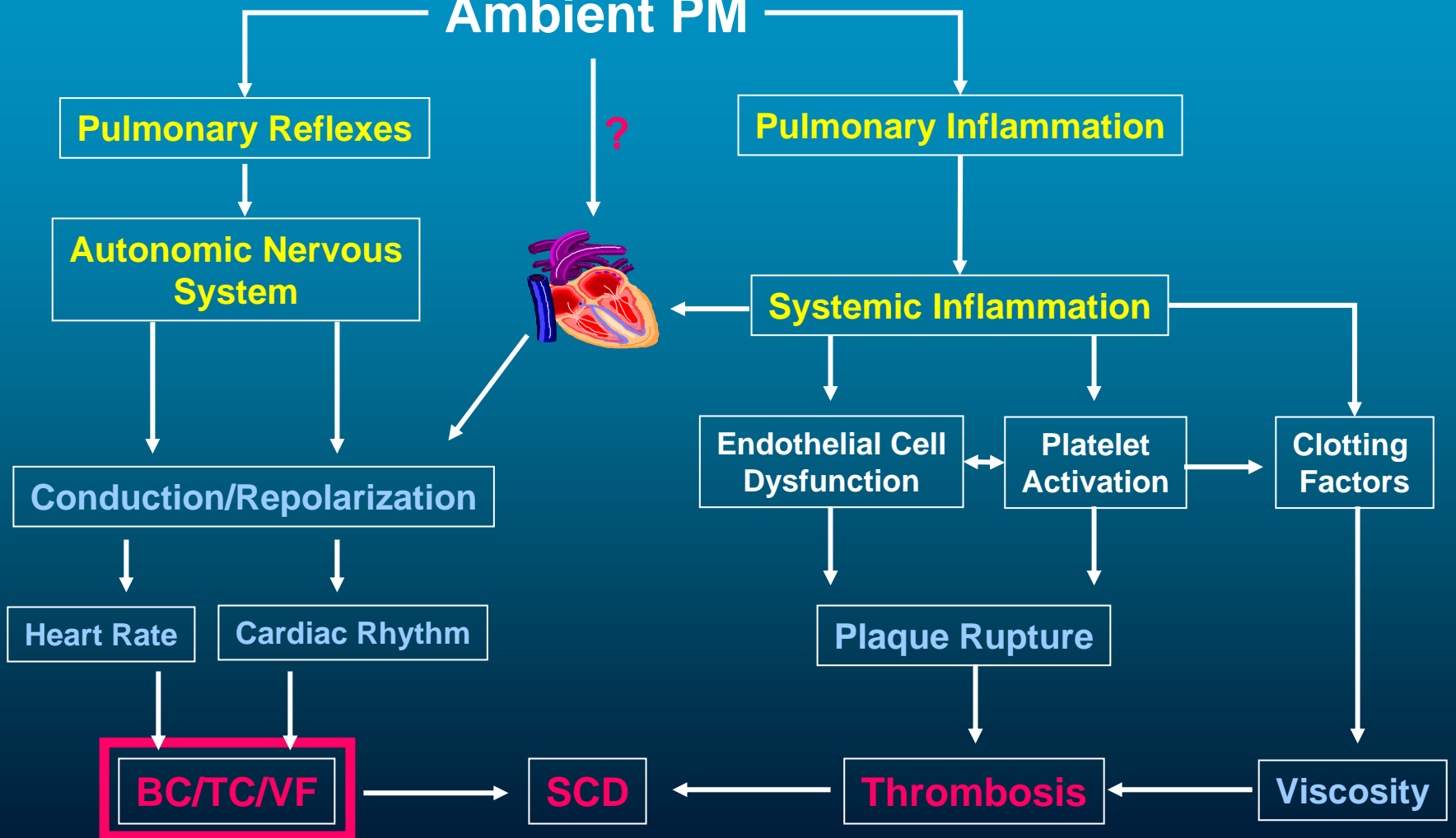
Watkinson et al. (2000)

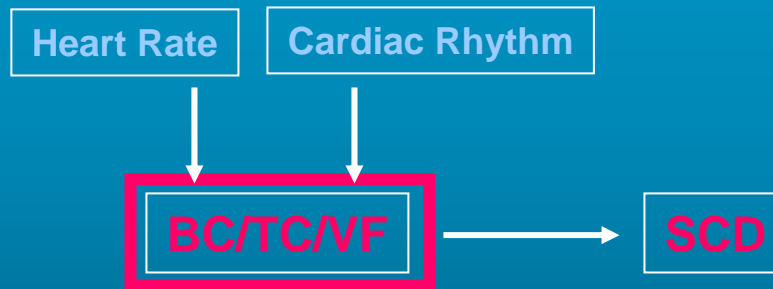
HR decrease in older rats exposed to PM collected in Ottawa

Godleski et al. (2000)

HR decrease in dogs exposed to CAPS

# Ambient PM





Costa et al. (1997)

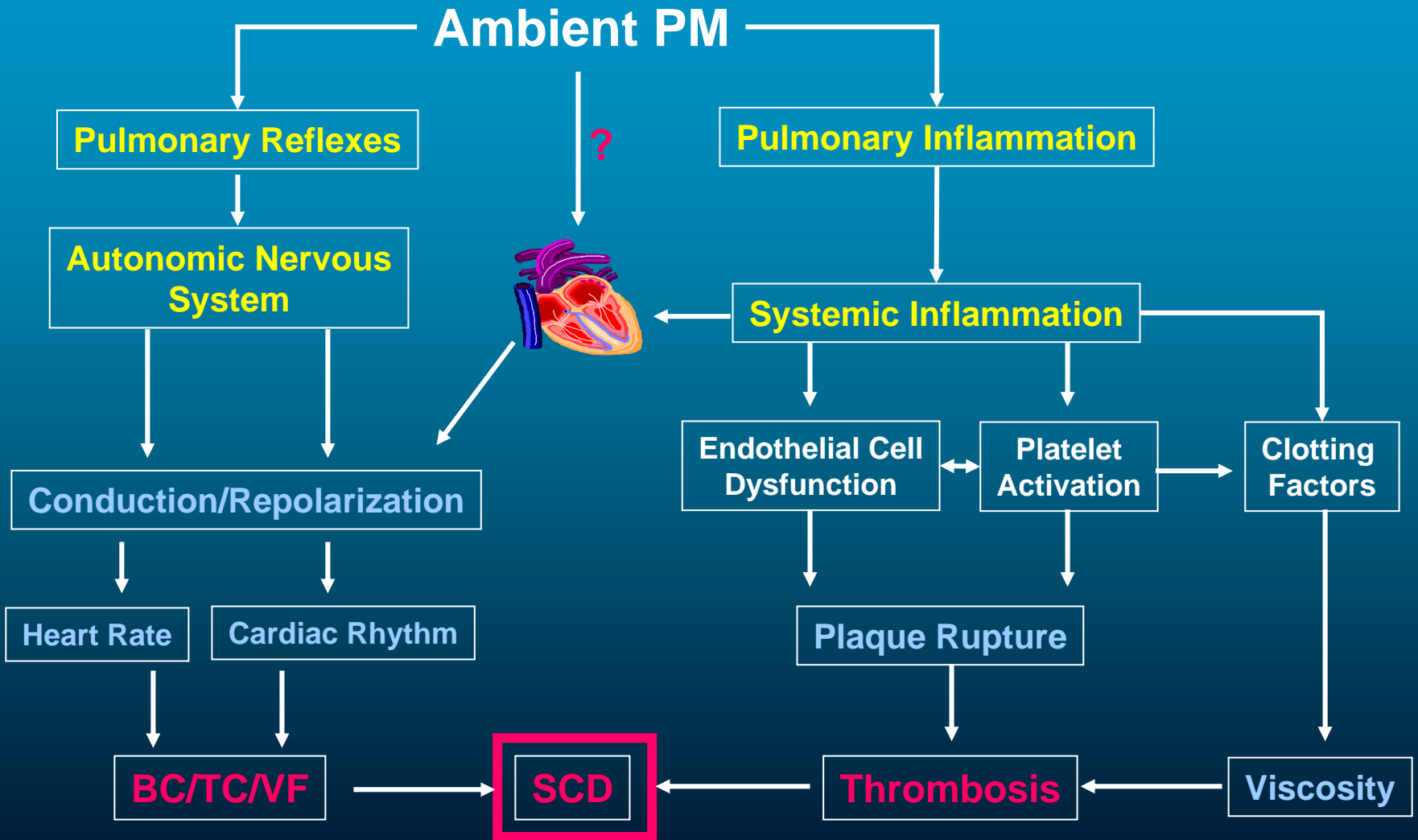
Severe arrhythmias in monocrotaline treated rats exposed to ROFA

Muggenburg et al. (2000)

Slight bradycardia in dogs exposed to ROFA

Watkinson et al. (2000)

Increased arrhythmias in older rats exposed to PM collected in  
Ottawa





Killingsworth et al. (1997)

Significant mortality in monocrotaline treated rats exposed to ROFA

Peters et al. (2000)

Association between exposure to PM and increased implanted defibrillator discharge

Peters et al. (2001)

Risk for MI onset increased in association with PM exposure 2 hours before the MI