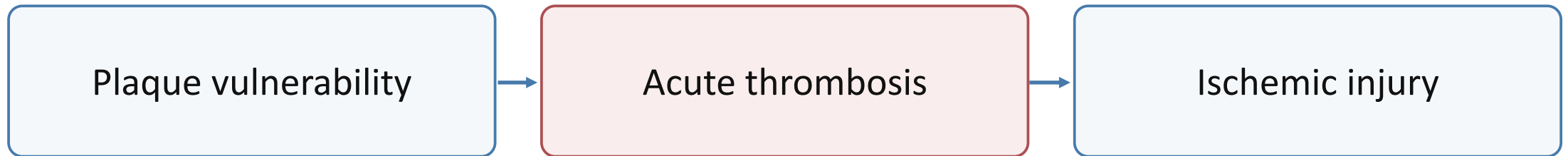


Acute Plaque Change

Rupture · Erosion · Intraplaque hemorrhage



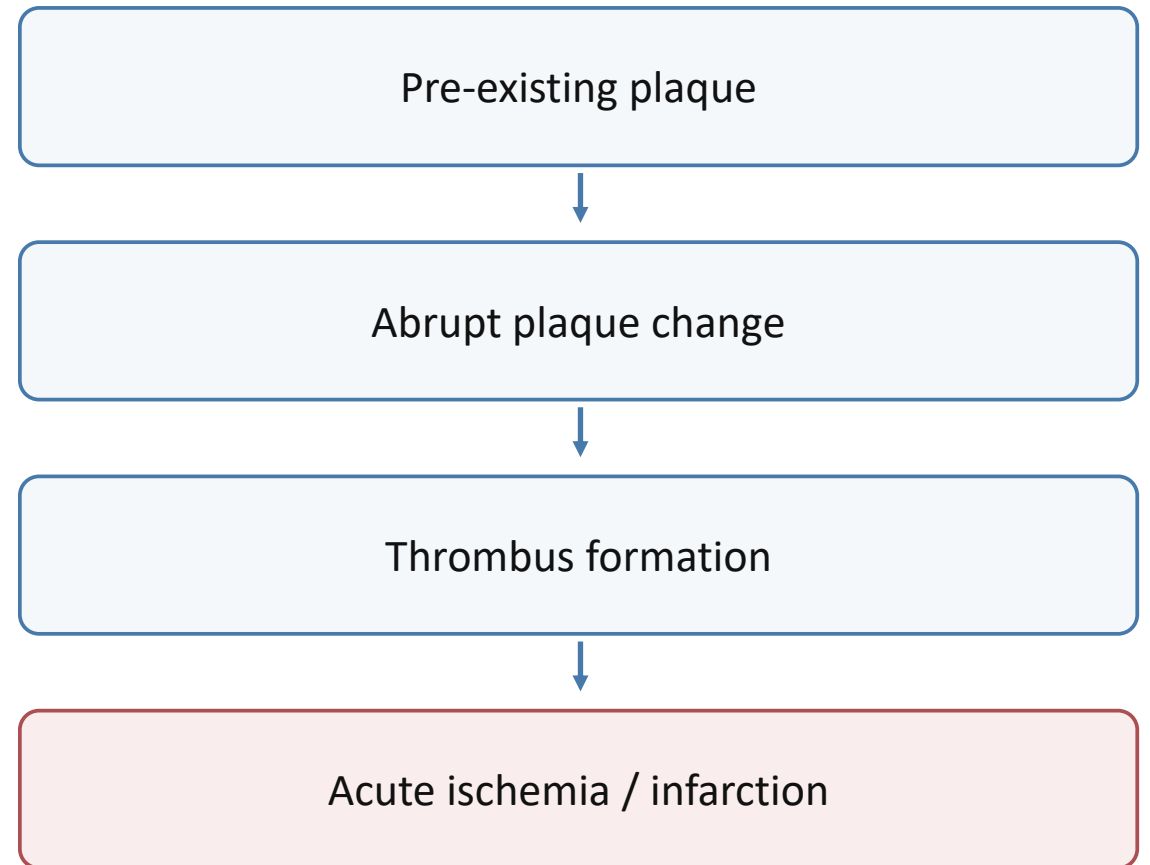
Dr Abu Suraih Sakhri

MBBS, MD (Pathology)

www.abusuraihsakhri.com

Acute plaque change: A mechanism of sudden ischemia

- A long-standing atheroma can become clinically dangerous over a short interval.
- Surface disruption exposes thrombogenic material and recruits thrombus.
- A coronary or cerebral artery may become critically obstructed without preceding severe fixed stenosis.



Learning objectives

- Distinguish plaque rupture, erosion, and intraplaque hemorrhage.
- Relate fibrous-cap architecture to mechanical vulnerability.
- Explain intrinsic and extrinsic triggers of plaque disruption.
- Trace thrombosis, embolization, and healing to clinical outcomes.

Forms of injury

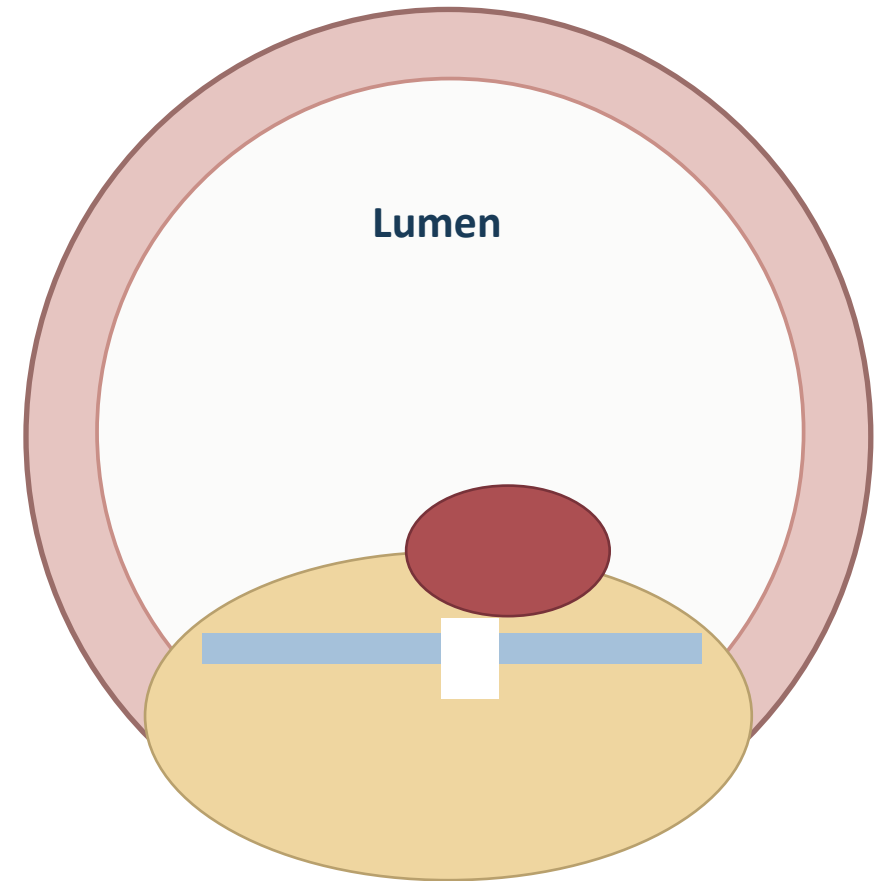
Structural vulnerability

Triggers

Tissue consequences

What constitutes an acute plaque change?

- A sudden structural alteration of an established intimal atheroma.
- Acute change is distinct from gradual plaque enlargement and fixed stenosis.
- Thrombosis is the major immediate determinant of many catastrophic events.



Rupture / clot — schematic

Chronic stenosis and acute complications are different pathways

- Stable fibroatheromas may progressively reduce perfusion under increased demand.
- Abrupt surface changes create an immediate thrombogenic interface.
- Both mechanisms arise from atherosclerosis but need not coincide in the same lesion.

PATHWAY 1

Gradual luminal narrowing

Fixed flow limitation

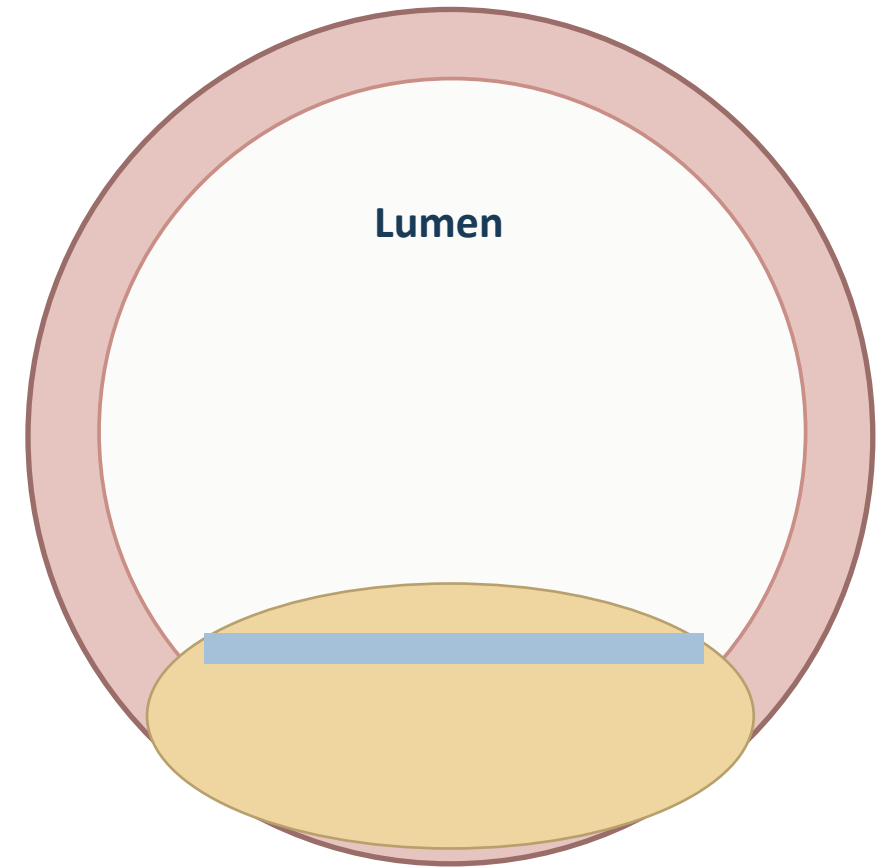
PATHWAY 2

Abrupt disruption + thrombus

Sudden loss of perfusion

Anatomic substrate: A plaque in the intima

- Atheroma is an intimal lesion beneath the luminal endothelial surface.
- The fibrous cap overlies a lipid-rich necrotic core.
- Shoulder regions may be enriched in macrophages and lymphocytes.
- Underlying medial structure can be compressed by a growing lesion.



Fibrous cap — schematic

Composition of the mature atheroma

- Smooth muscle cells and collagen constitute much of the fibrous cap.
- Macrophages, T lymphocytes, and foam cells contribute to cellular components.
- Extracellular lipid, dead-cell debris, and variable calcifications populate the core.
- Small new vessels may occur toward plaque periphery.

SMCs + collagen

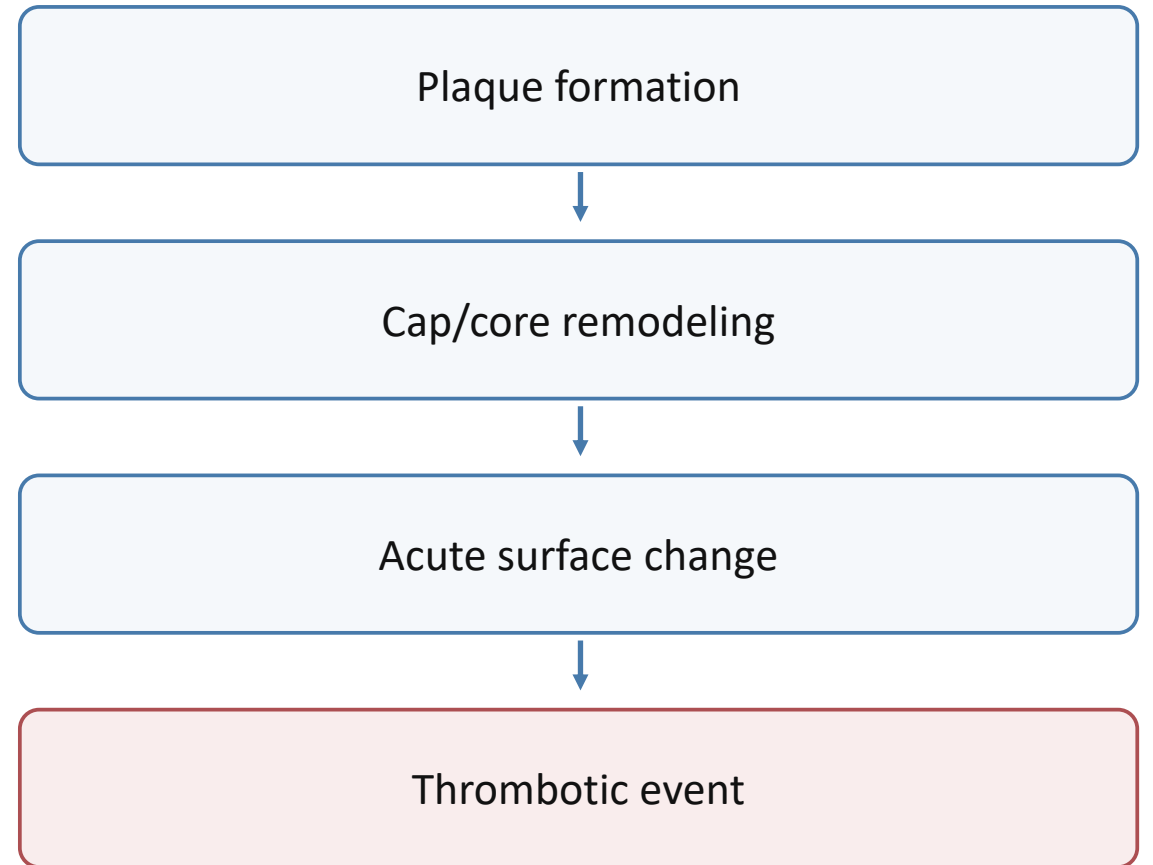
Inflammatory cells

Necrotic / lipid core

Neovessels, calcification

Slow progression can precede abrupt clinical conversion

- Atheromas accumulate lipids, cells, and extracellular matrix over years.
- Later cap erosion or rupture can trigger thrombosis in a brief interval.
- A prior period without angina does not establish plaque stability.



Fixed narrowing does not fully predict acute risk

- Many culprit coronary plaques were noncritical before an acute event.
- Mechanical fragility and blood thrombogenicity matter in addition to lumen diameter.
- Angiographic appearance alone cannot reliably forecast plaque rupture.

PATHWAY 1

Anatomic stenosis

Degree of lumen loss

PATHWAY 2

Biologic vulnerability

Cap/core + inflammation +
triggers

Three principal forms of acute plaque change

- Rupture or fissuring: Fibrous-cap disruption with exposure of highly thrombogenic plaque constituents.
- Erosion or ulceration: Loss of protective luminal surface with exposure of subendothelial matrix.
- Hemorrhage: Bleeding into the plaque, increasing lesion volume.

Rupture / fissure



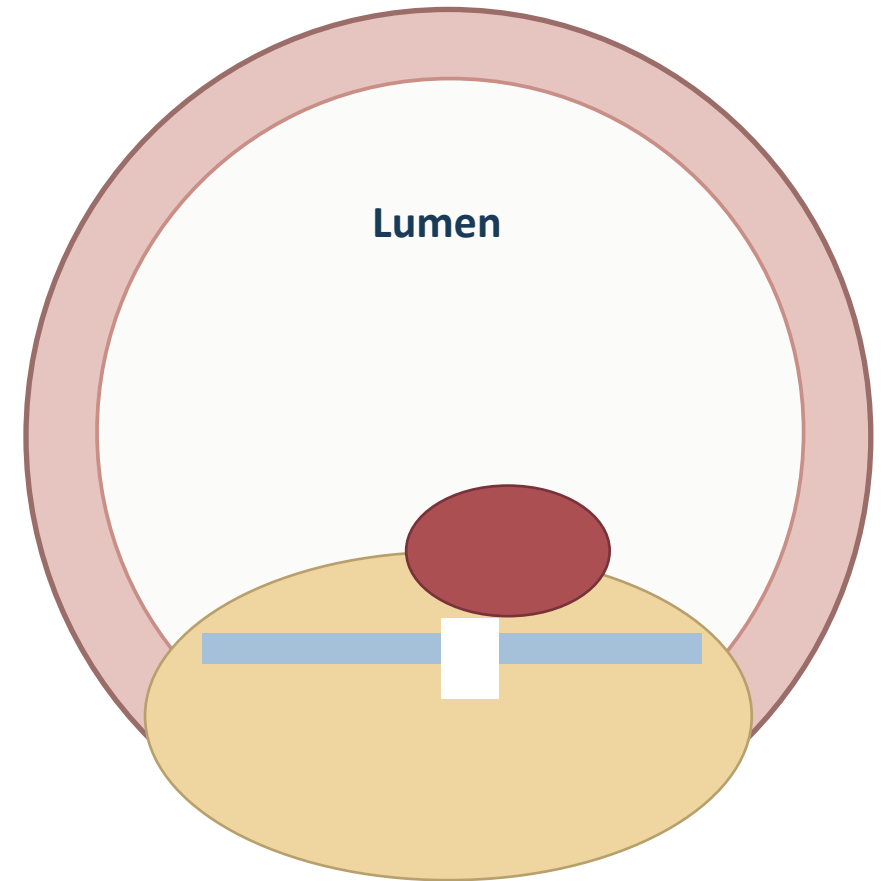
Erosion / ulceration



Intraplaque hemorrhage

Plaque rupture is a structural failure of the cap

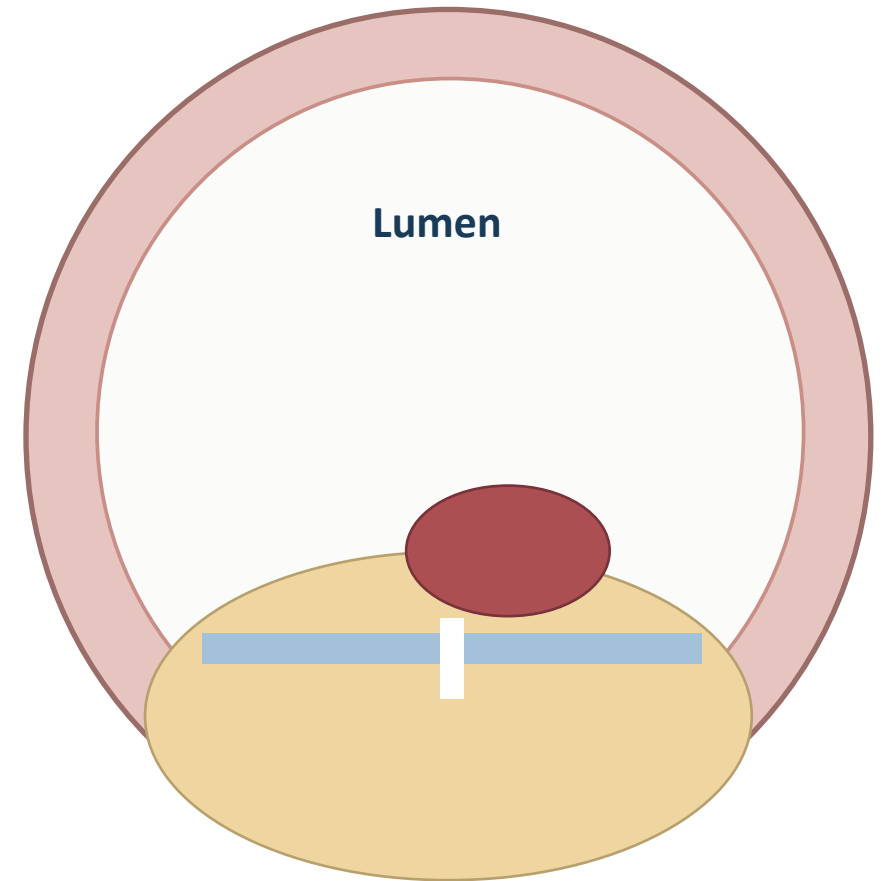
- Cap disruption establishes communication between flowing blood and plaque core.
- Highly thrombogenic contents initiate coagulation and platelet deposition.
- The resulting luminal thrombus can become completely obstructive.



Rupture / clot — schematic

Fissuring may be focal rather than extensive

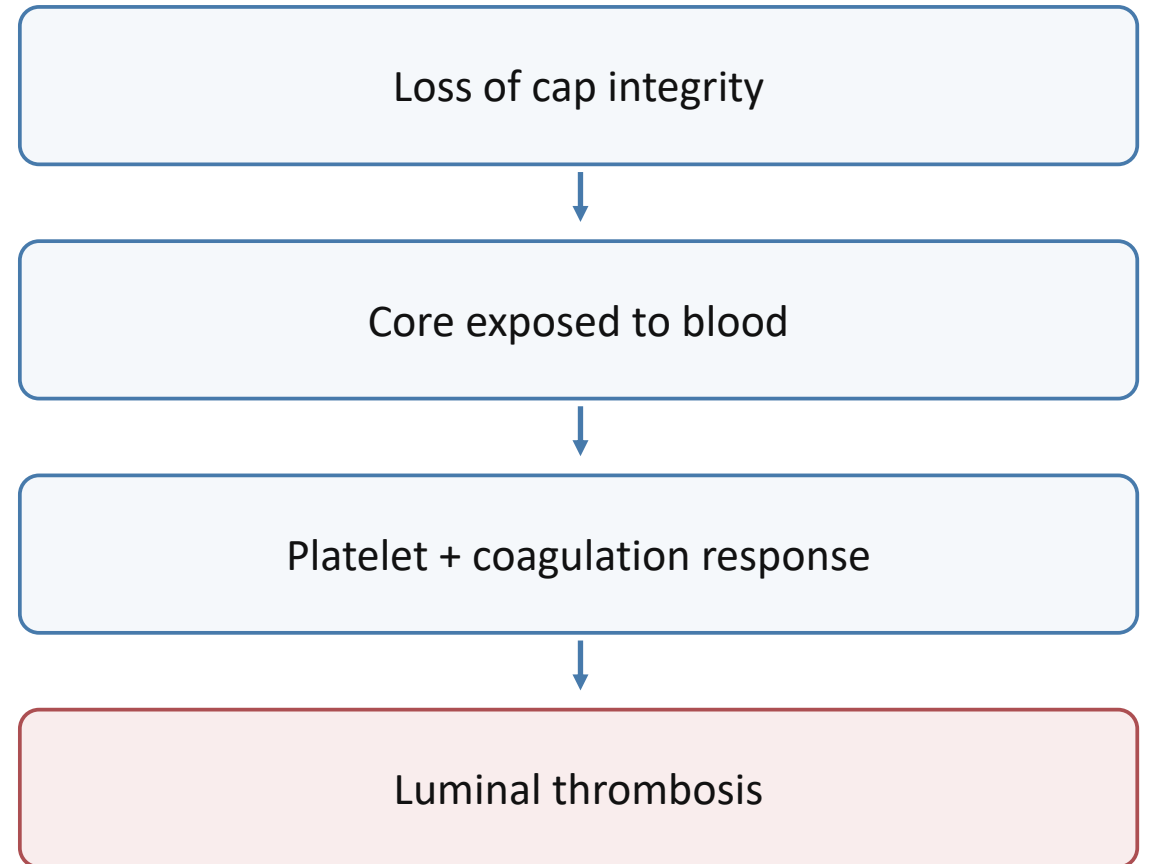
- Even localized cap breaks can expose thrombogenic material.
- Rupture severity and thrombus extent are separate variables.
- The overlying blood clot may obscure a relatively small plaque defect.



Rupture / clot — schematic

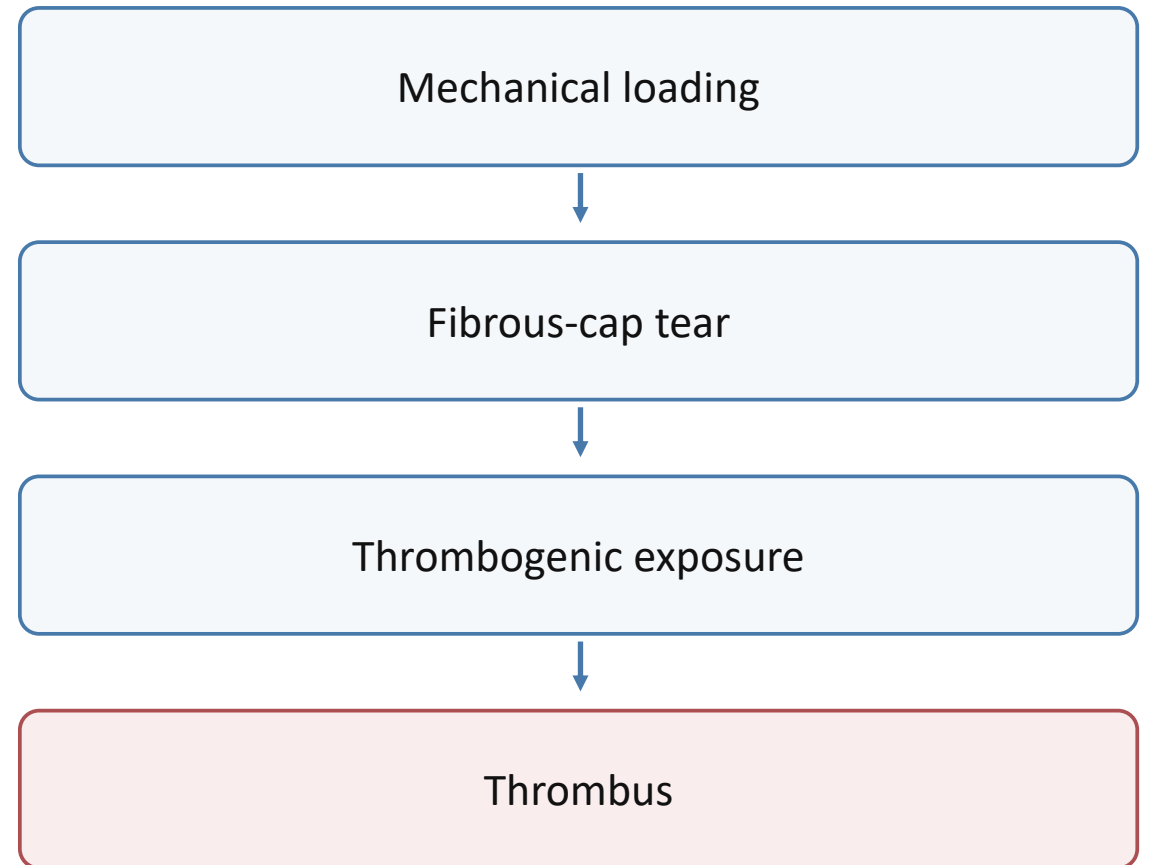
The necrotic core is thrombogenic when exposed

- Plaque core contains lipid, necrotic debris, and blood-derived proteins.
- A torn cap allows these constituents to contact flowing blood.
- Tissue factor–dependent coagulation, together with platelet activation, favors thrombus growth.



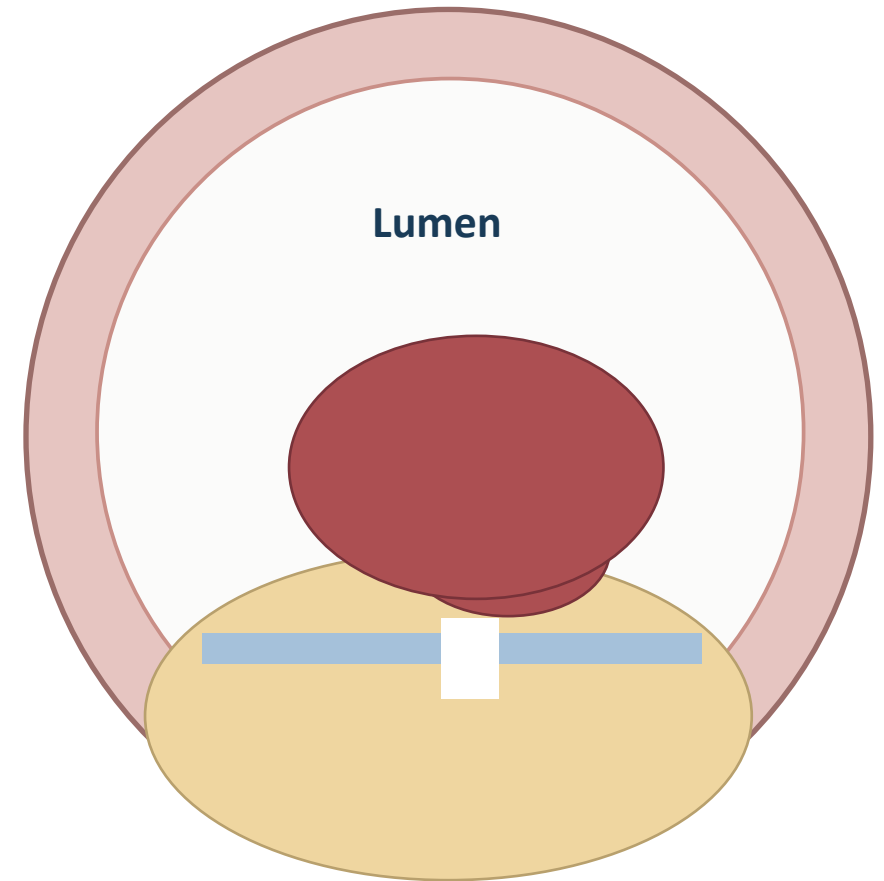
Rupture: From mechanical tear to thrombus

- A vulnerable cap fails when local stress exceeds its resistance.
- Blood contacts underlying plaque contents at the site of failure.
- Activated platelets and coagulation products form a growing thrombus.



Why thrombus after rupture can be occlusive

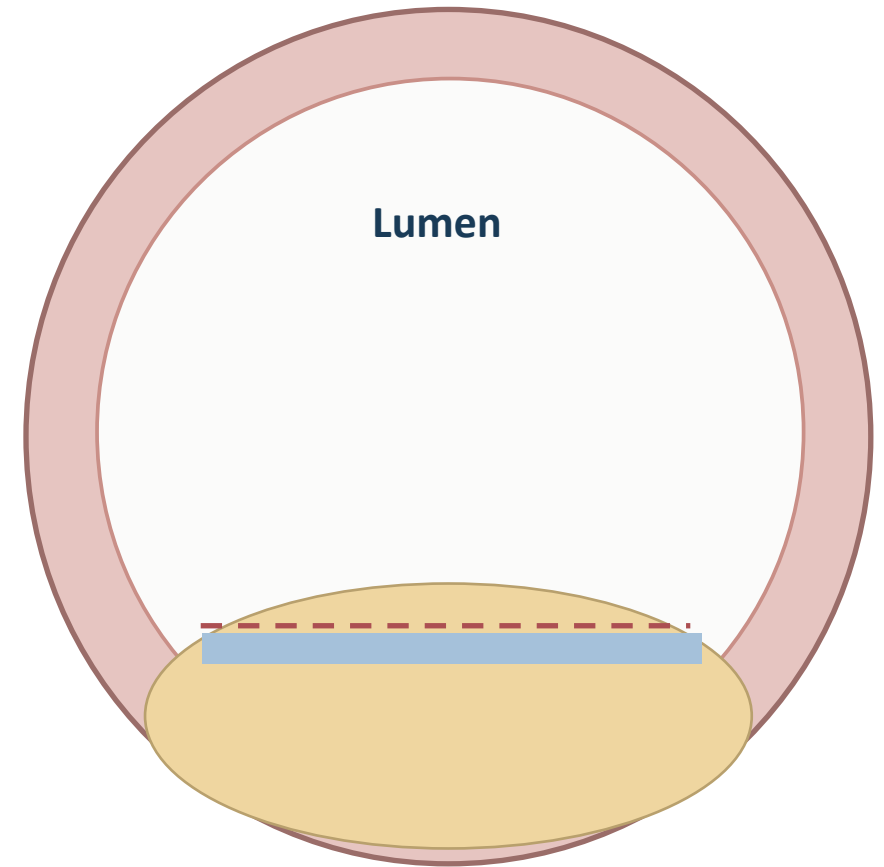
- Rupture directly exposes particularly thrombogenic plaque material.
- Coagulation and platelet accumulation can rapidly narrow the available lumen.
- Complete obstruction may cause acute downstream infarction.



Rupture / clot — schematic

Plaque erosion denotes surface loss with an intact cap

- Erosion involves endothelial loss and exposure of the subendothelial matrix.
- The fibrous cap need not rupture into the necrotic core.
- The denuded luminal surface can nevertheless support platelet-rich thrombosis.



Eroded surface — schematic

The endothelium protects blood from matrix exposure

- An intact endothelial lining separates circulating platelets from subendothelial structures.
- Surface denudation removes this antithrombotic barrier.
- Exposure of the basement membrane facilitates platelet adhesion and thrombosis.

PATHWAY 1

Intact endothelial
interface

Matrix separated from
blood

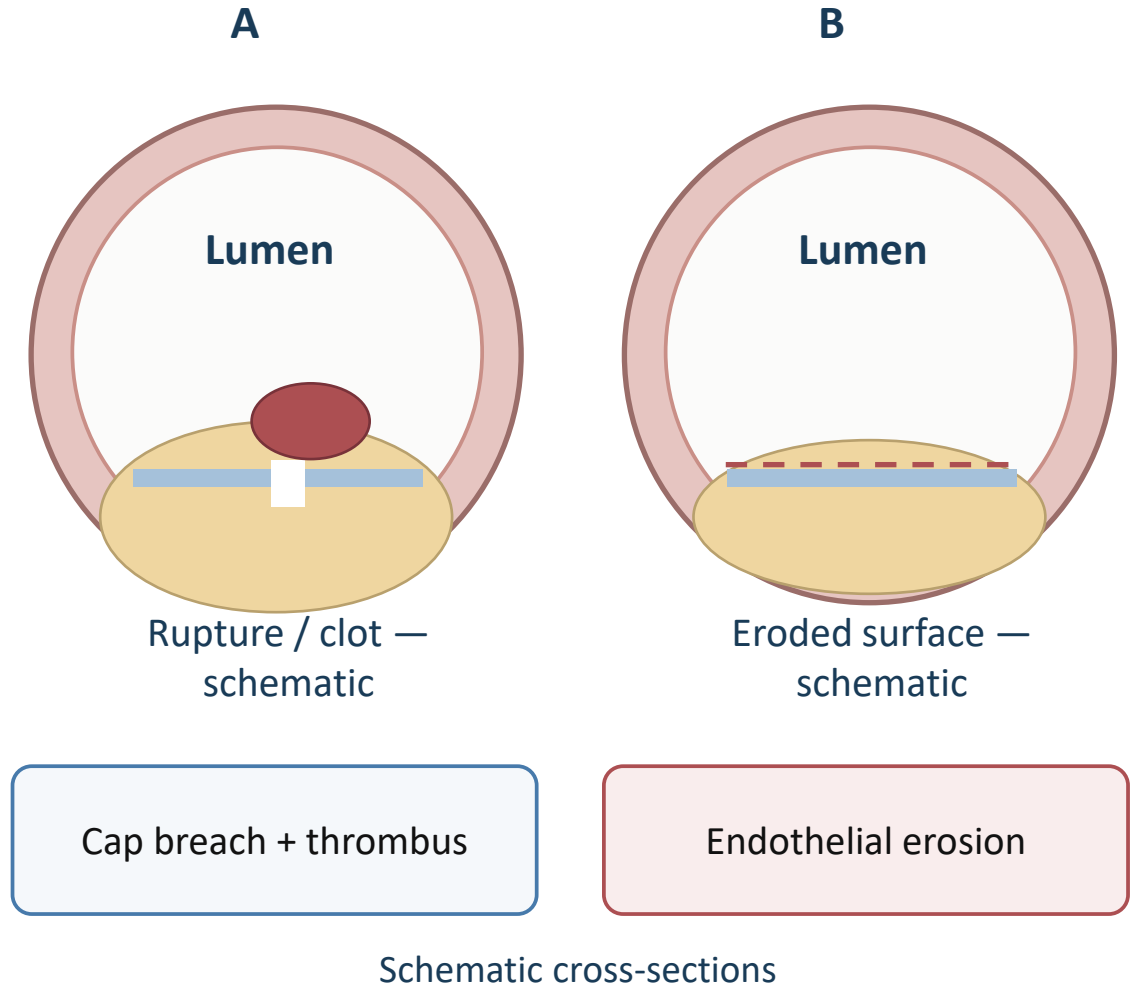
PATHWAY 2

Denuded luminal
interface

Thrombogenic matrix
accessible

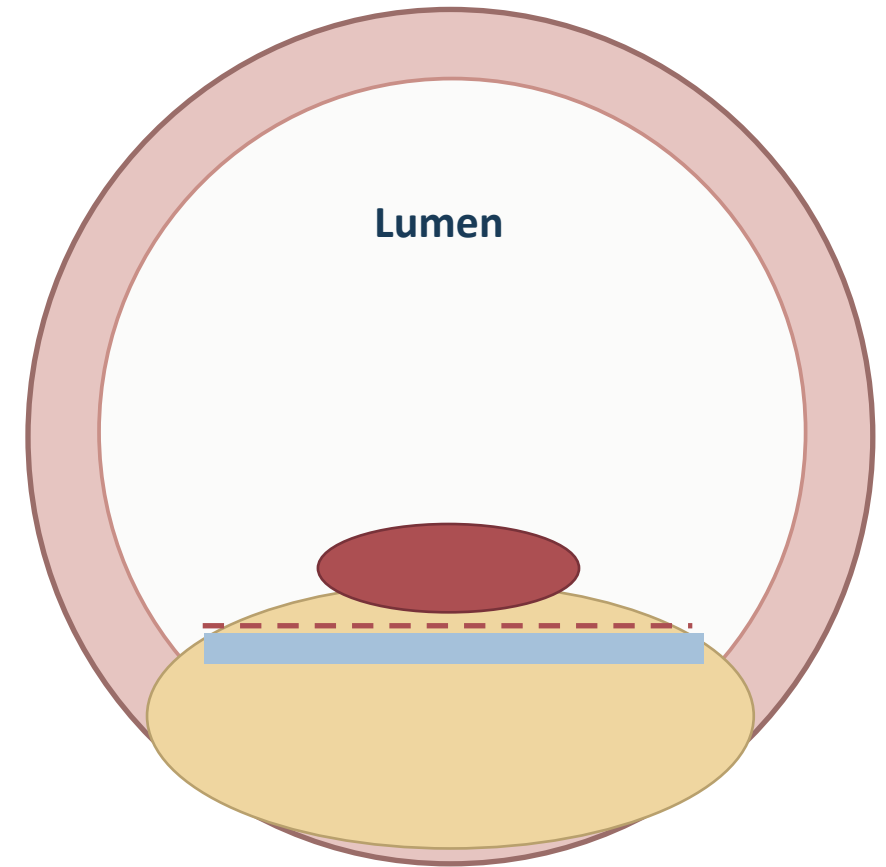
Erosion and rupture are not equivalent lesions

- Rupture has a breach in the fibrous cap and access to the underlying core.
- Erosion can create thrombus despite an intact cap.
- Both can present clinically with abrupt ischemia, but their tissue-level mechanisms differ.



Erosion can produce nonocclusive thrombosis

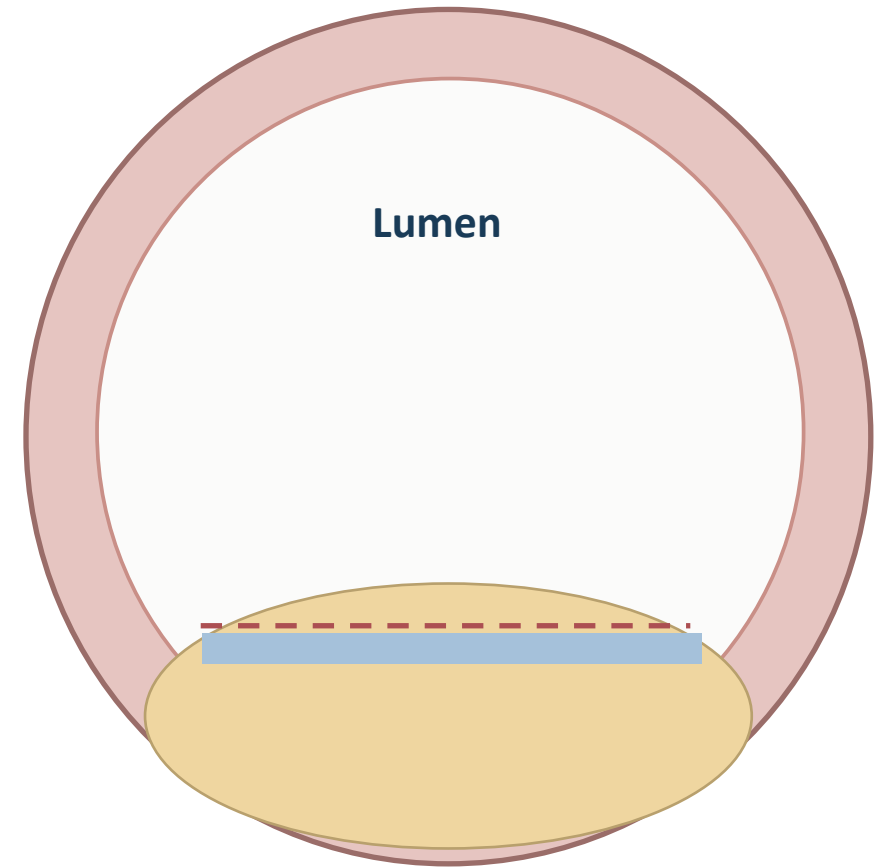
- Exposed subendothelial matrix can recruit thrombus on the plaque surface.
- Fully occlusive thrombosis occurs less often than with rupture.
- The magnitude of residual flow depends on thrombus burden and vasomotor tone.



Eroded surface — schematic

Ulceration describes destructive surface injury

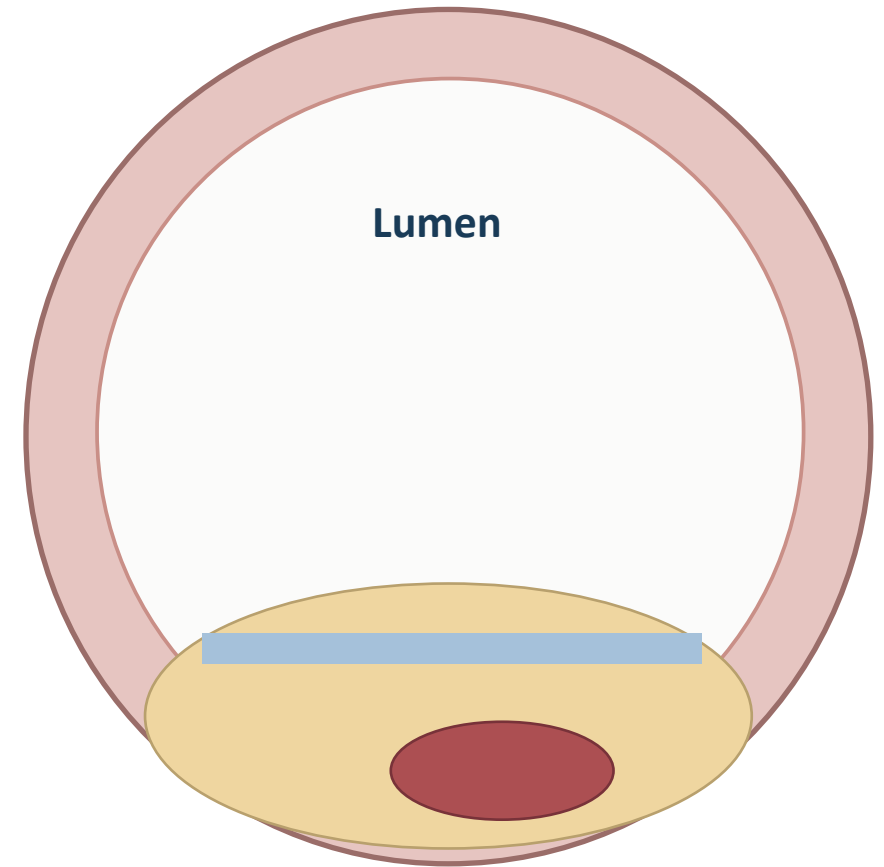
- Surface ulceration removes the normal luminal covering of the plaque.
- Exposed thrombogenic surfaces promote clot formation.
- In the acute-change classification, ulceration is discussed with erosion.



Eroded surface — schematic

Intraplaque hemorrhage adds blood within the atheroma

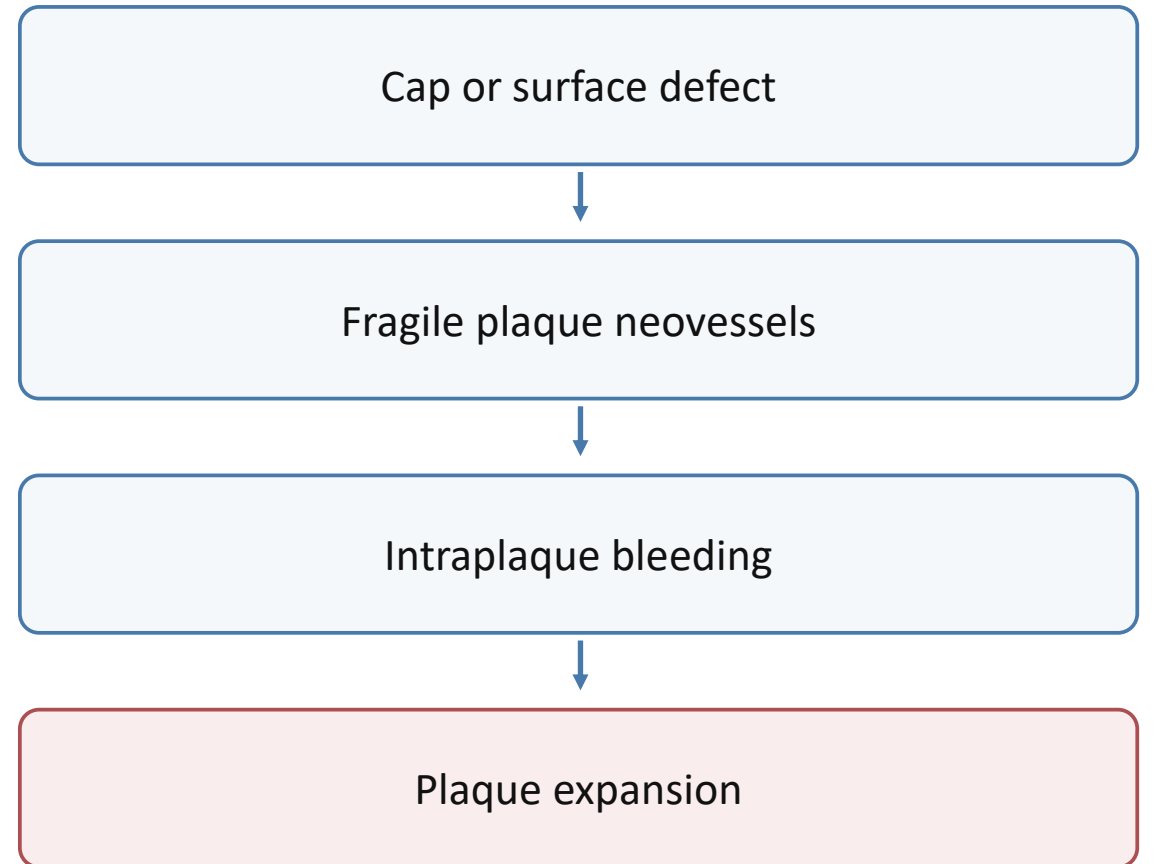
- Hemorrhage enlarges the plaque core or its immediate surroundings.
- The resulting volume expansion can increase luminal compromise.
- A contained hemorrhage may also increase tension on the overlying cap.



Hemorrhage — schematic

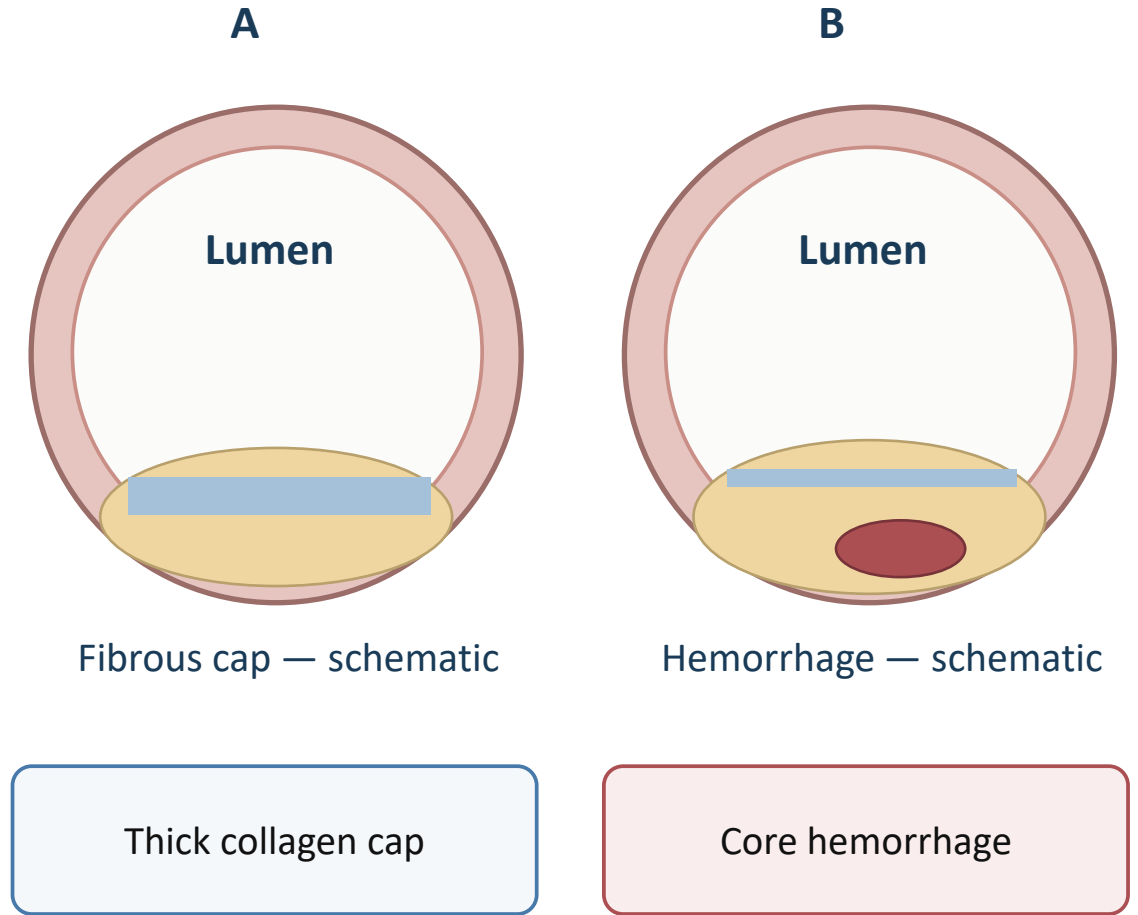
How blood may enter an atherosclerotic plaque

- A defect in the surface can permit bleeding into the lesion.
- Thin-walled neovessels at the plaque periphery can also bleed.
- Both routes contribute to increased plaque volume.



Hemorrhage may acutely enlarge the stenosing mass

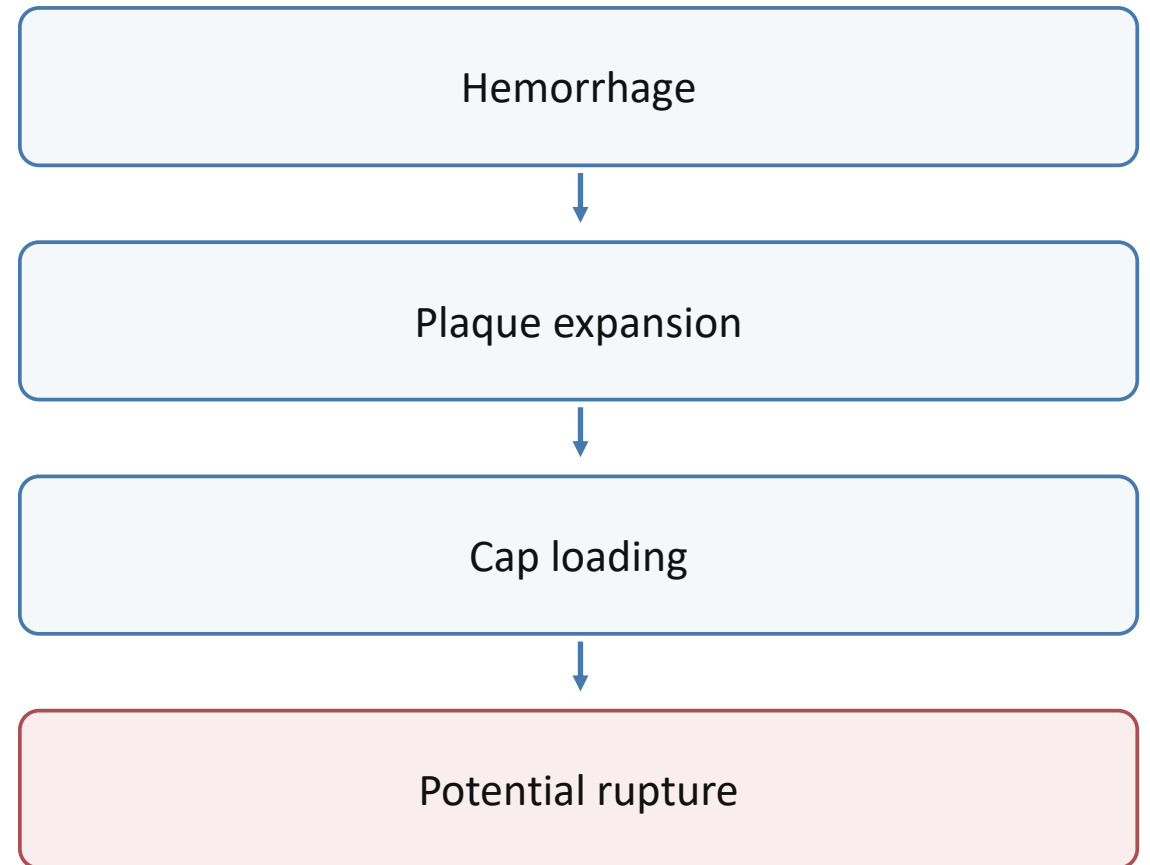
- The same arterial lumen now faces a larger intimal protrusion.
- Acute mass effect is distinct from thrombus deposited inside the lumen.
- Greater plaque volume may precipitate additional cap stress.



Schematic cross-sections

Hemorrhage and rupture can reinforce one another

- Intraplaque hemorrhage can increase internal plaque pressure and deformation.
- Cap disruption may itself be associated with hemorrhage into the lesion.
- Thus intraplaque bleeding is both an acute plaque event and a possible contributor to further disruption.



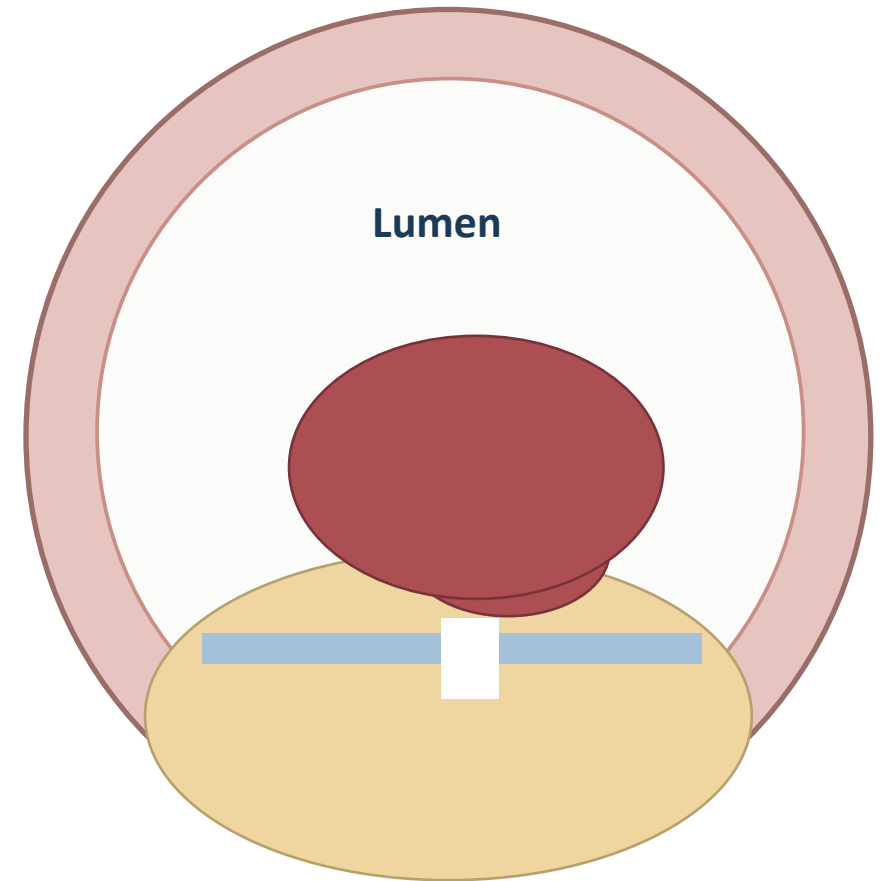
Mechanism-level comparison of the three forms

- Rupture exposes plaque-core constituents to blood.
- Erosion removes luminal endothelial protection without necessarily breaking the cap.
- Hemorrhage expands the plaque itself and may add to stenosis or instability.

Finding / insult	Process	Immediate effect
Rupture	Cap/core communication	Thrombosis
Erosion	Loss of luminal surface	Thrombosis
Hemorrhage	Bleeding into lesion	Plaque expansion

Surface thrombosis is the critical acute interface

- Both rupture and erosion can lead promptly to thrombus formation.
- The thrombus—not simply the original plaque mass—often causes the abrupt flow deficit.
- Acutely formed clot can be mural, subtotal, or occlusive.



Rupture / clot — schematic

Culprit plaques may have been clinically silent

- Clinical silence does not imply absence of atherosclerosis.
- Many plaques causing acute coronary occlusion had produced only mild or moderate prior narrowing.
- Sudden disruption creates a risk that is not captured by symptoms alone.

PATHWAY 1

Before event

Mild/moderate stenosis

PATHWAY 2

After rupture

Thrombus occupies lumen

A lumenogram cannot show every component of risk

- Conventional angiography primarily depicts the vascular lumen.
- Cap composition, inflammation, and necrotic-core properties affect rupture susceptibility.
- Standard angiography is therefore inadequate to predict an individual future rupture.

PATHWAY 1

Lumen-focused view

Residual lumen appears acceptable

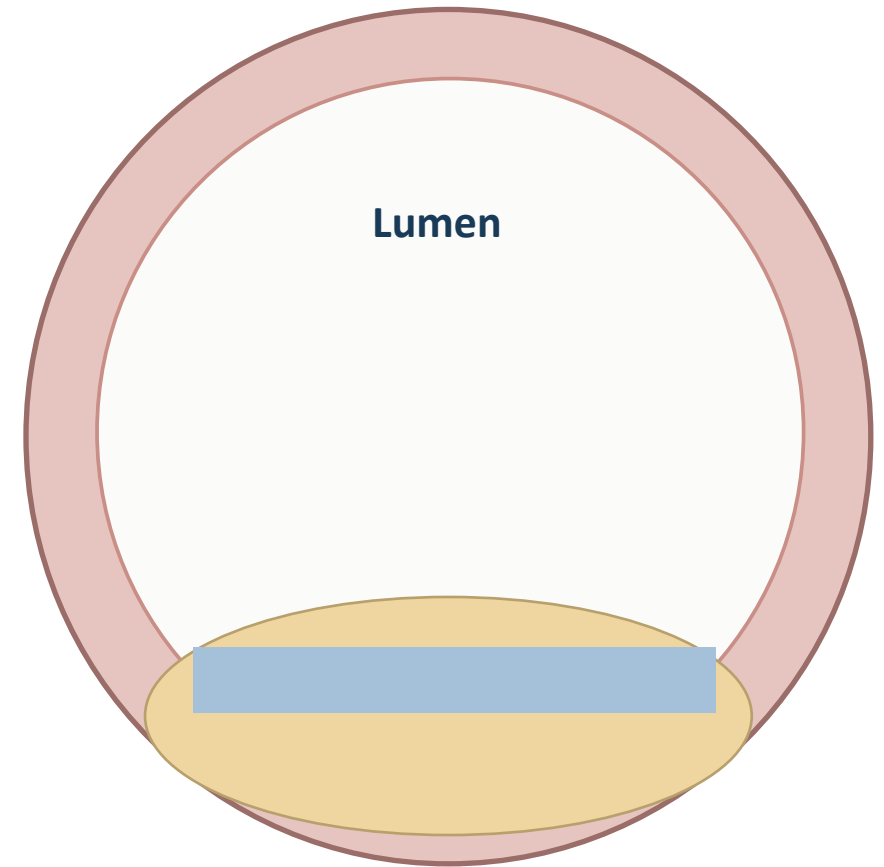
PATHWAY 2

Wall pathology

Thin cap + inflamed core

A relatively stable fibrous plaque

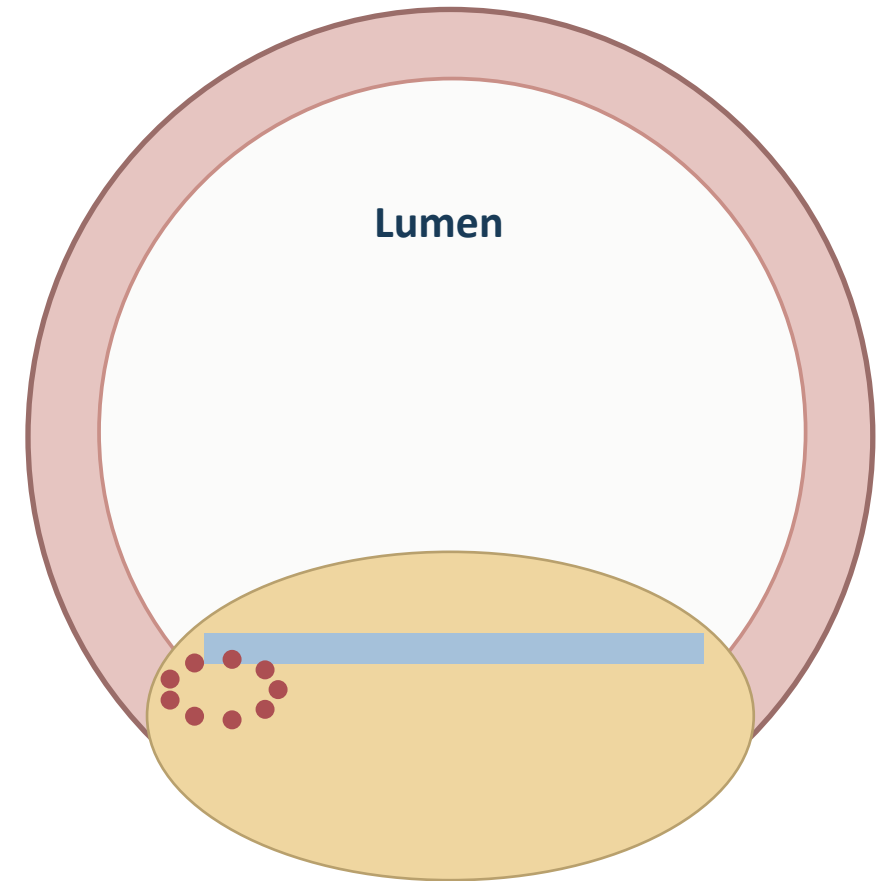
- A broad, collagen-rich cap resists mechanical loading.
- Relatively little inflammation limits collagen breakdown.
- Less lipid-rich necrotic material leaves fewer features favoring rupture.



Fibrous cap — schematic

Features associated with plaque vulnerability

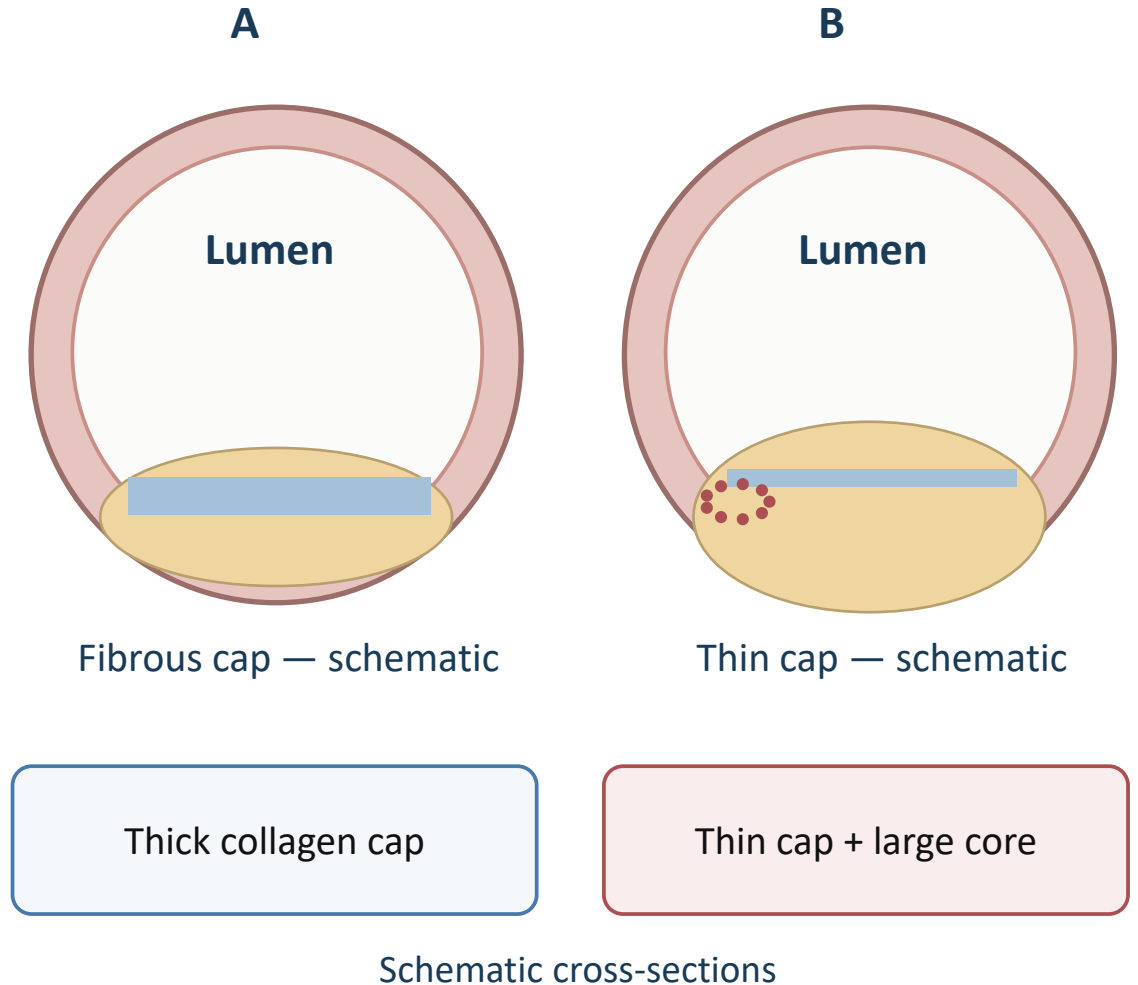
- Thin fibrous cap with diminished mechanical reserve.
- Relatively large necrotic lipid core beneath the cap.
- Inflammatory-cell infiltrates that promote matrix turnover.
- Less effective replacement of collagen by resident smooth muscle cells.



Thin cap — schematic

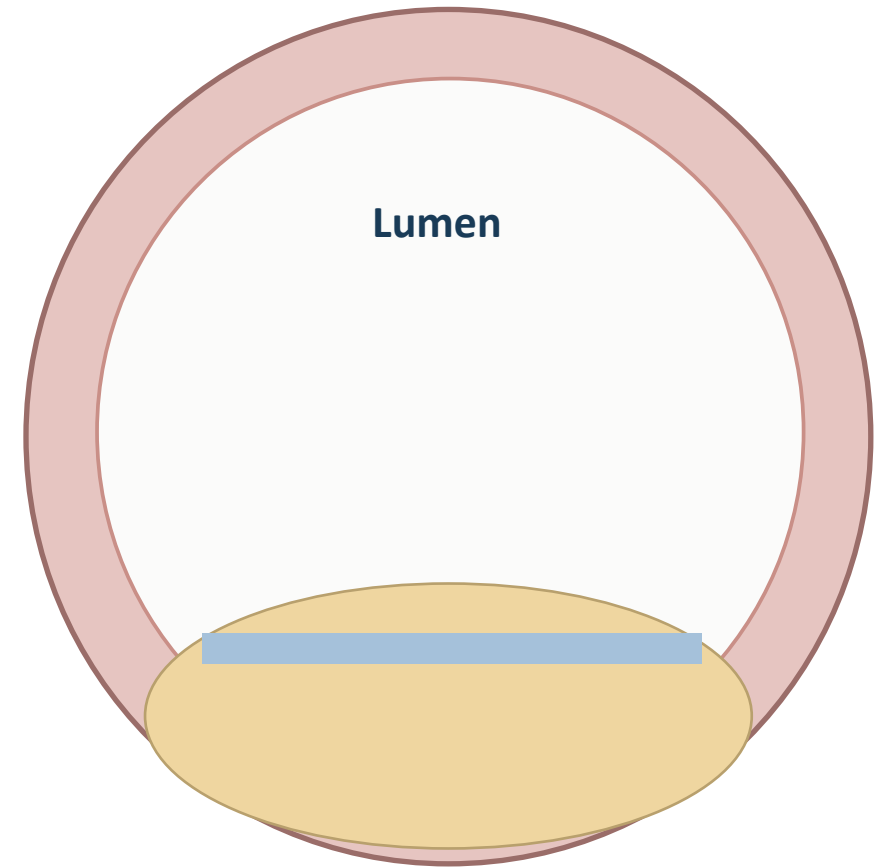
Plaque burden and plaque vulnerability are distinct

- Severely stenotic lesions may remain relatively fibrotic and stable.
- Less stenosing lesions may harbor thin caps and inflammatory activity.
- A pre-event degree of narrowing is not a sufficient surrogate for rupture probability.



The fibrous cap is the load-bearing structure

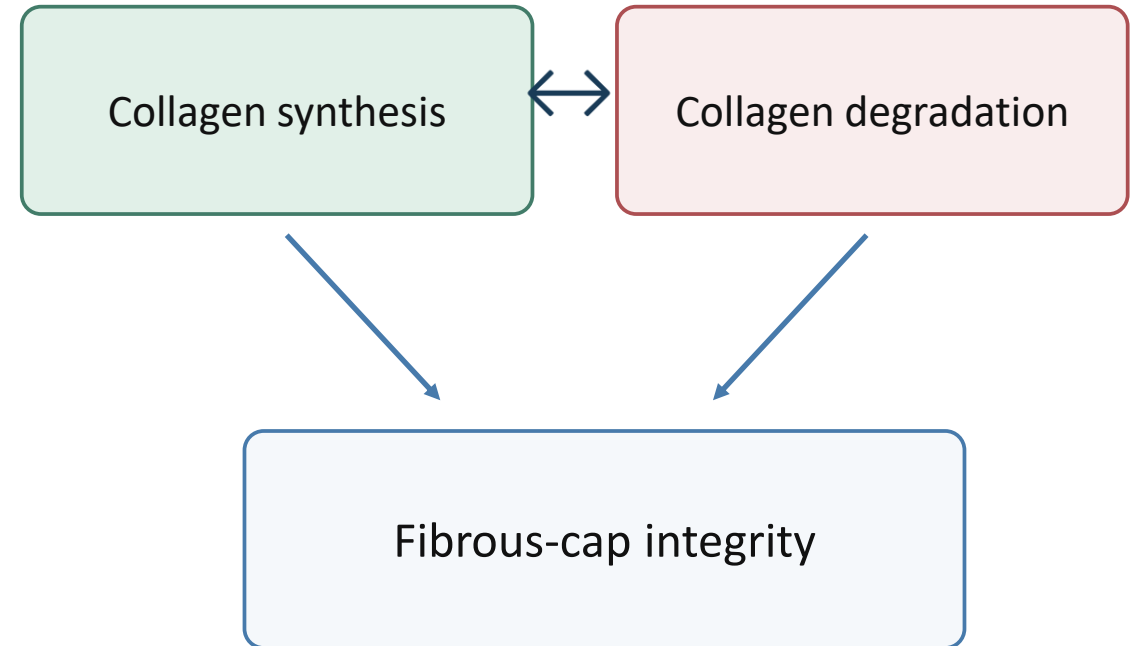
- Collagen-rich extracellular matrix supplies tensile strength.
- Smooth muscle cells contribute to maintenance of this cap.
- Thin or poorly maintained cap tissue fails more readily under local forces.



Fibrous cap — schematic

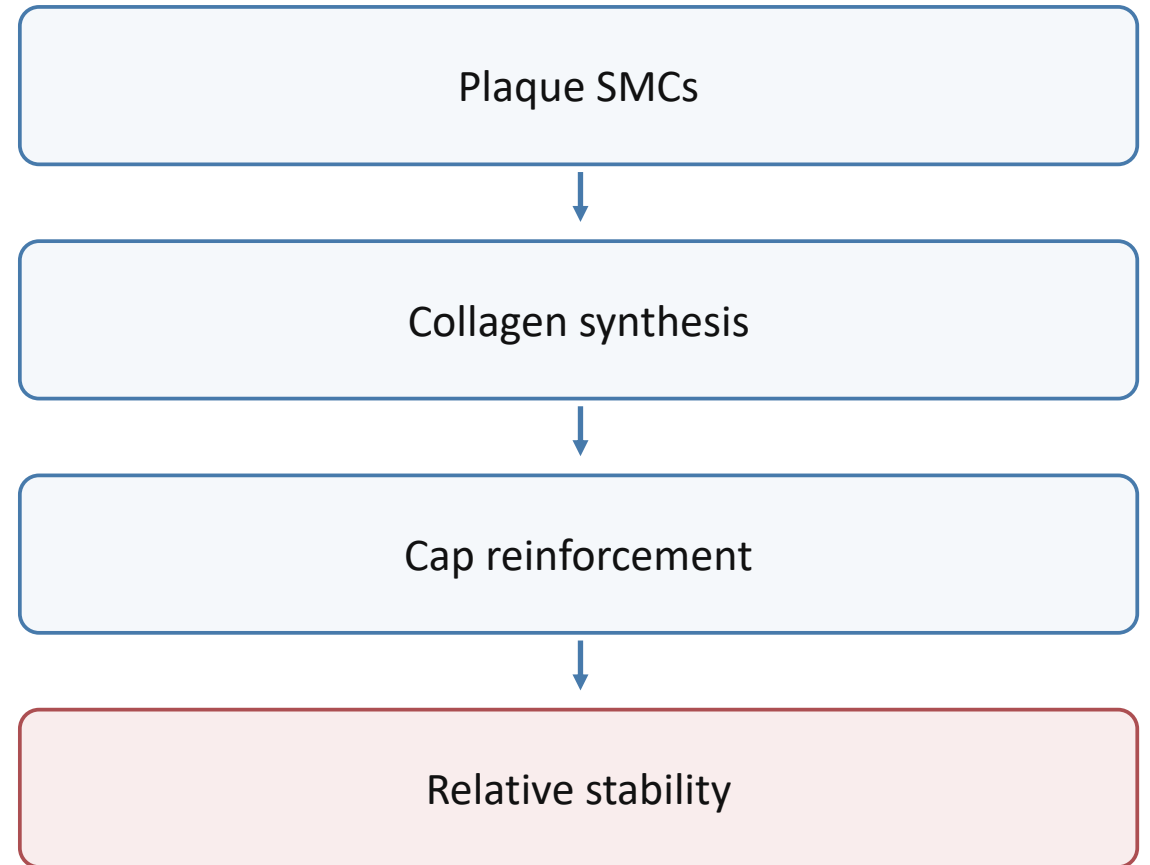
Collagen is the principal cap-strength determinant

- Collagen provides tensile support for the plaque surface.
- Loss of cap collagen weakens tissue resistance to shear and mechanical strain.
- Strength depends on the balance of collagen production and degradation.



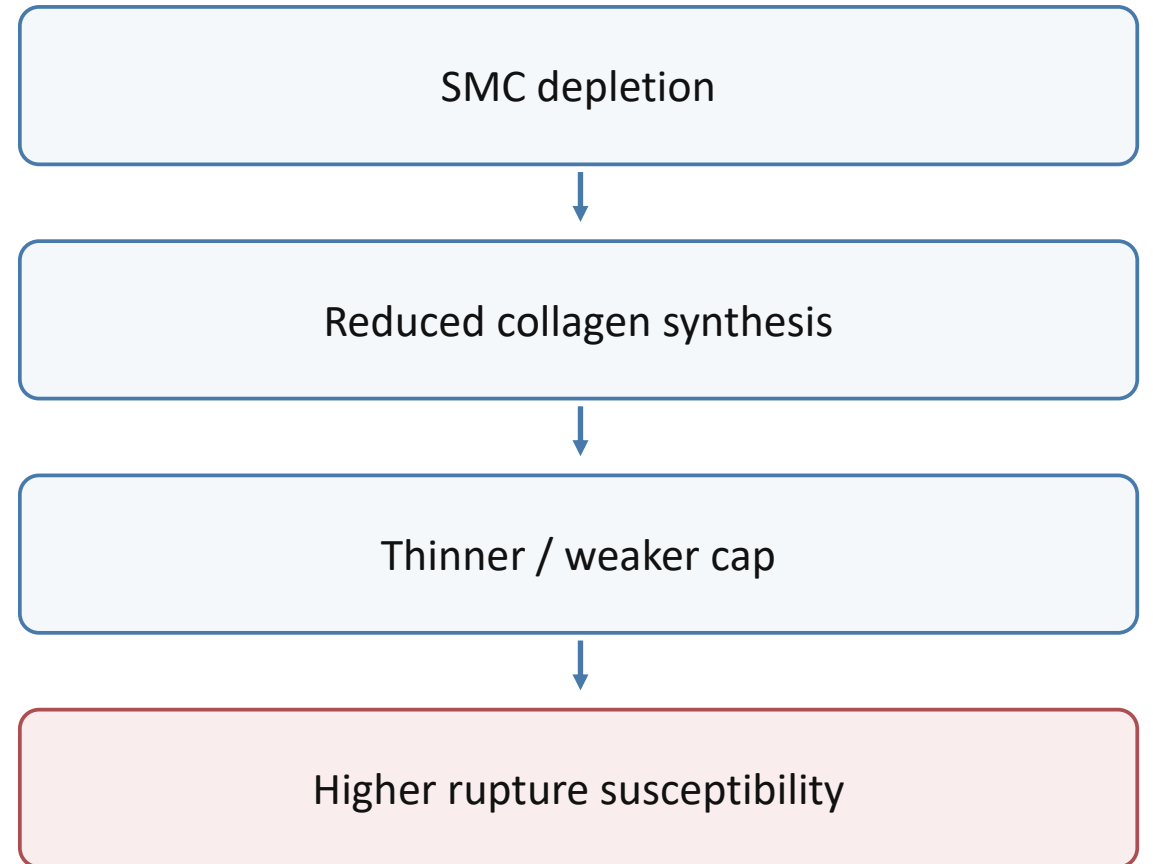
Smooth muscle cells synthesize protective collagen

- Plaque smooth muscle cells elaborate cap extracellular matrix.
- Their presence contributes to repair and stability.
- Loss or functional suppression of these cells reduces the capacity to replace collagen.



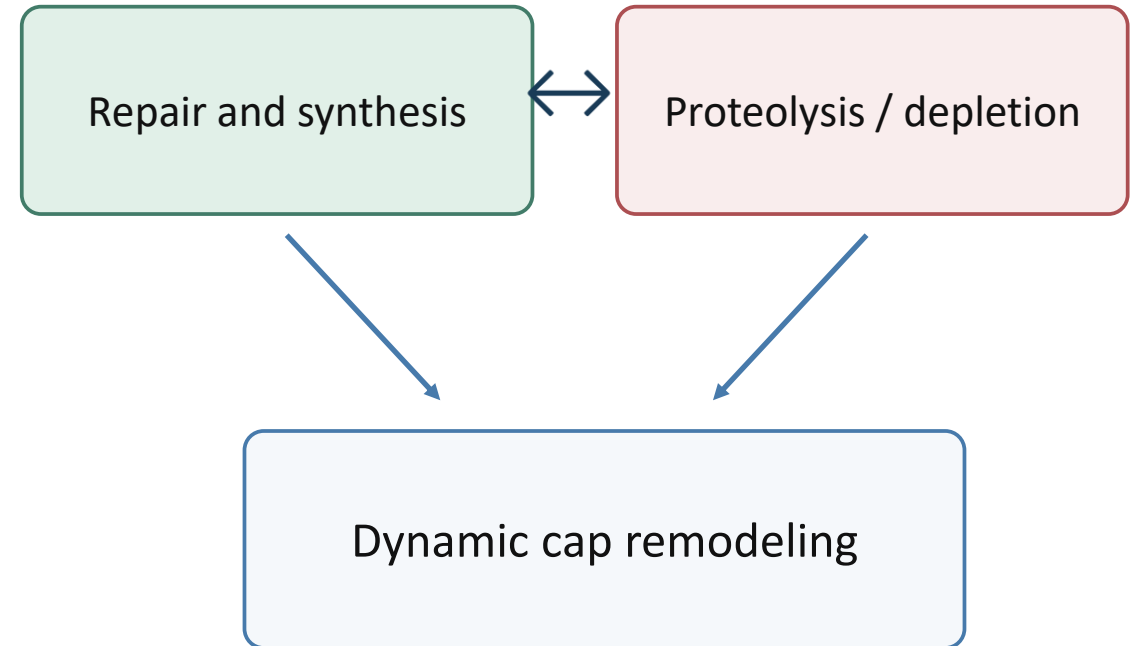
Loss of cap smooth muscle cells increases fragility

- Fewer matrix-producing cells leave a weaker repair response.
- A cap rich in inflammatory cells but poor in SMCs may be under-repaired.
- Reduced synthesis acts together with proteolytic degradation.



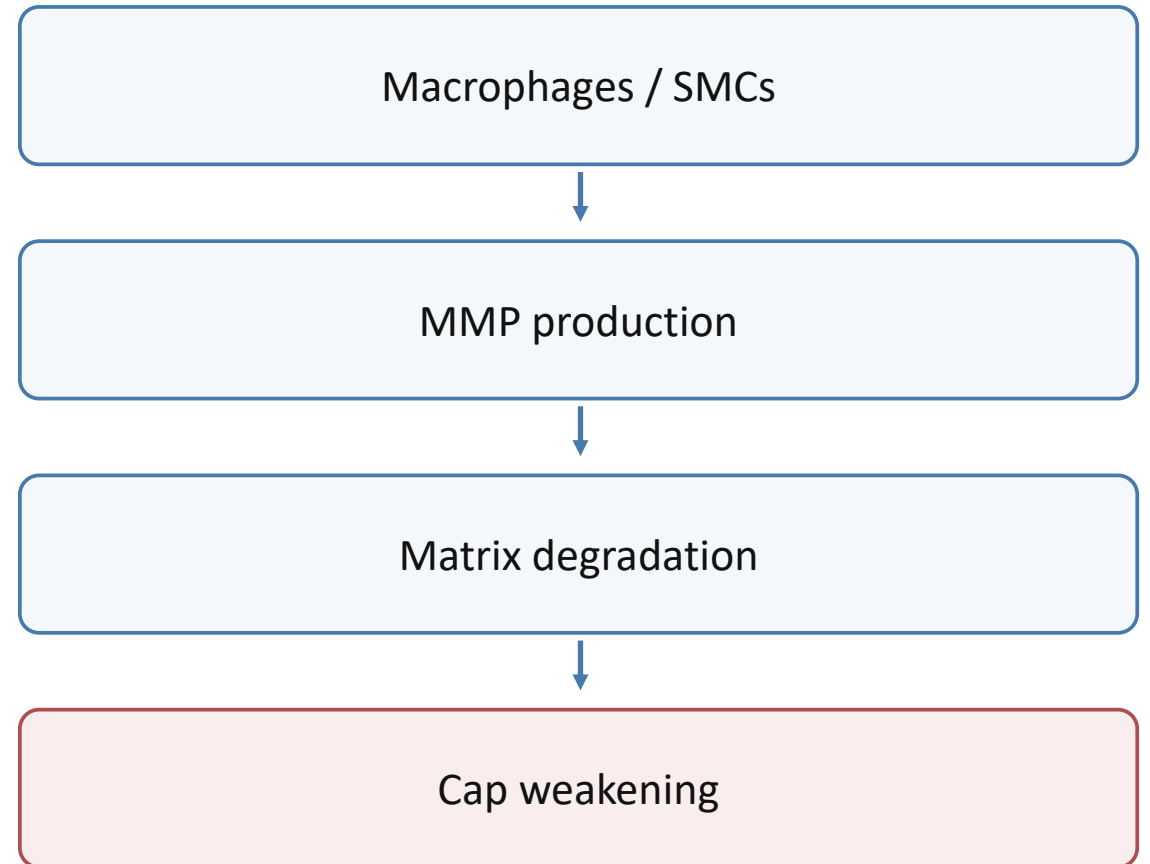
Cap remodeling is continuous, not static

- Fibrous cap collagen is constantly synthesized and degraded.
- The net direction of remodeling determines cap thickness and mechanical behavior.
- Stabilization and destabilization are dynamic, potentially reversible processes.



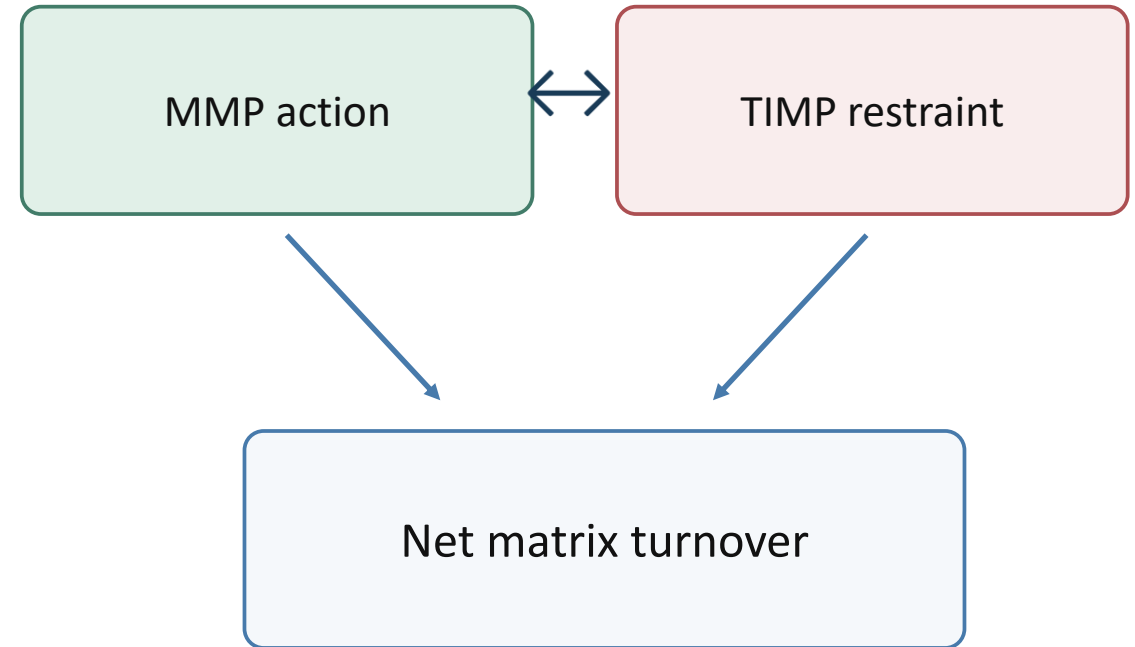
Matrix metalloproteinases degrade cap matrix

- MMPs participate in collagen breakdown inside plaques.
- Macrophages and smooth muscle cells are prominent sources of MMPs.
- Excess net proteolytic activity erodes the structural reserve of the fibrous cap.



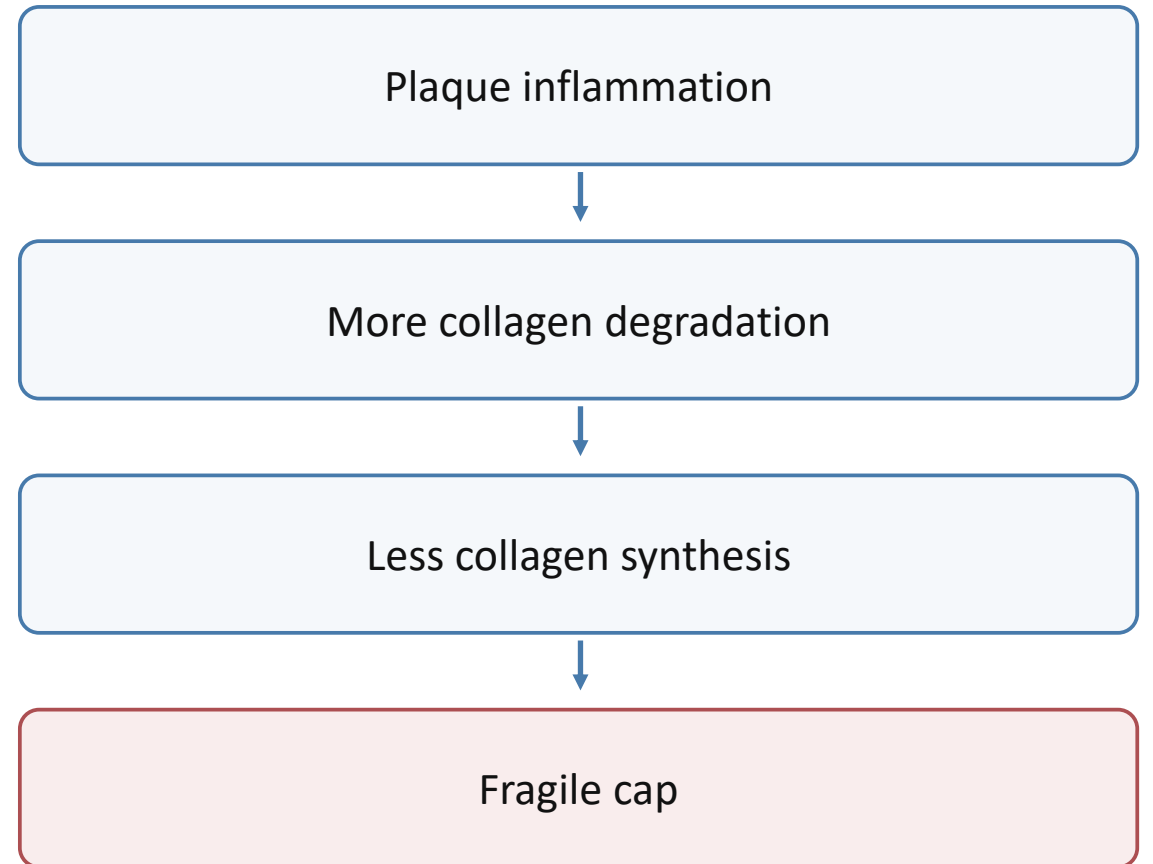
TIMPs temper metalloproteinase activity

- Tissue inhibitors of metalloproteinases (TIMPs) restrain MMP activity.
- Endothelial cells, smooth muscle cells, and macrophages can make TIMPs.
- Cap stability therefore depends on regulated proteolysis rather than MMP abundance alone.



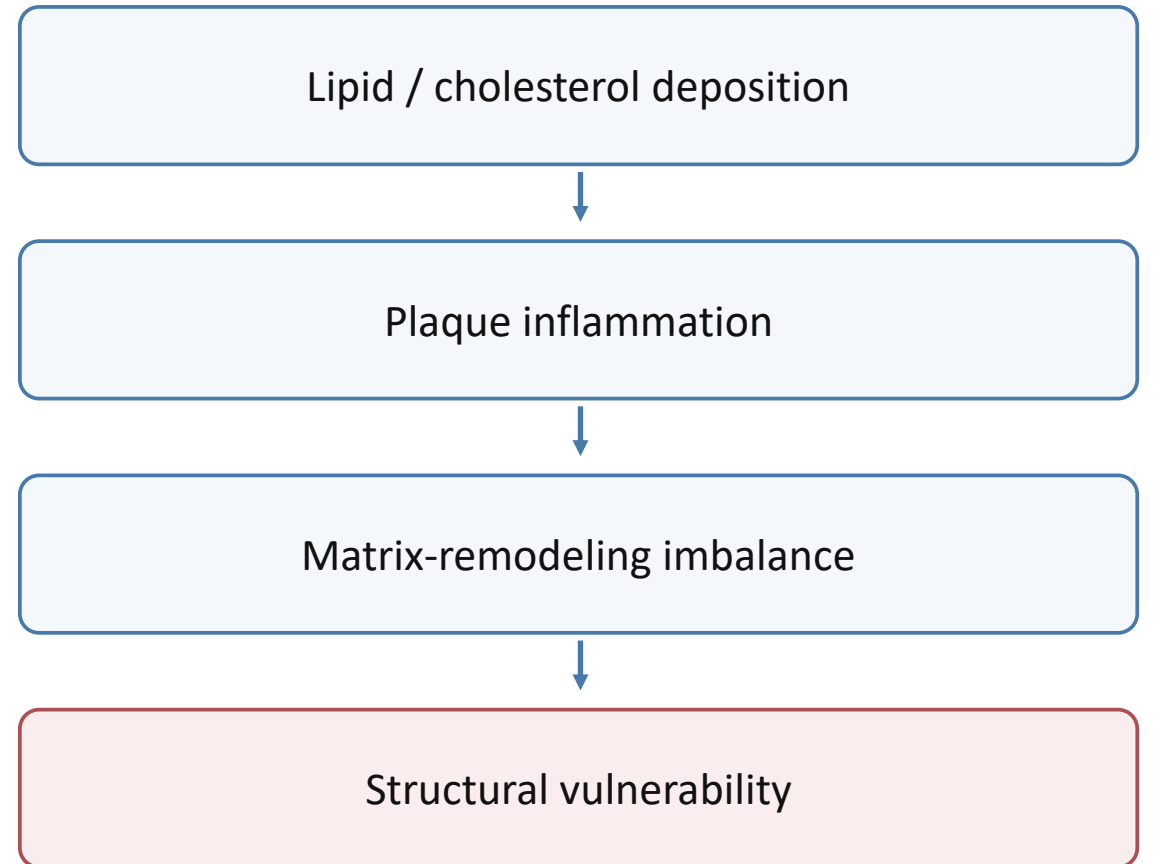
Inflammation alters both sides of collagen balance

- Inflammatory plaques exhibit increased matrix degradation.
- Collagen production may simultaneously decrease.
- The combined effect weakens the protective surface without requiring an increase in total plaque size.



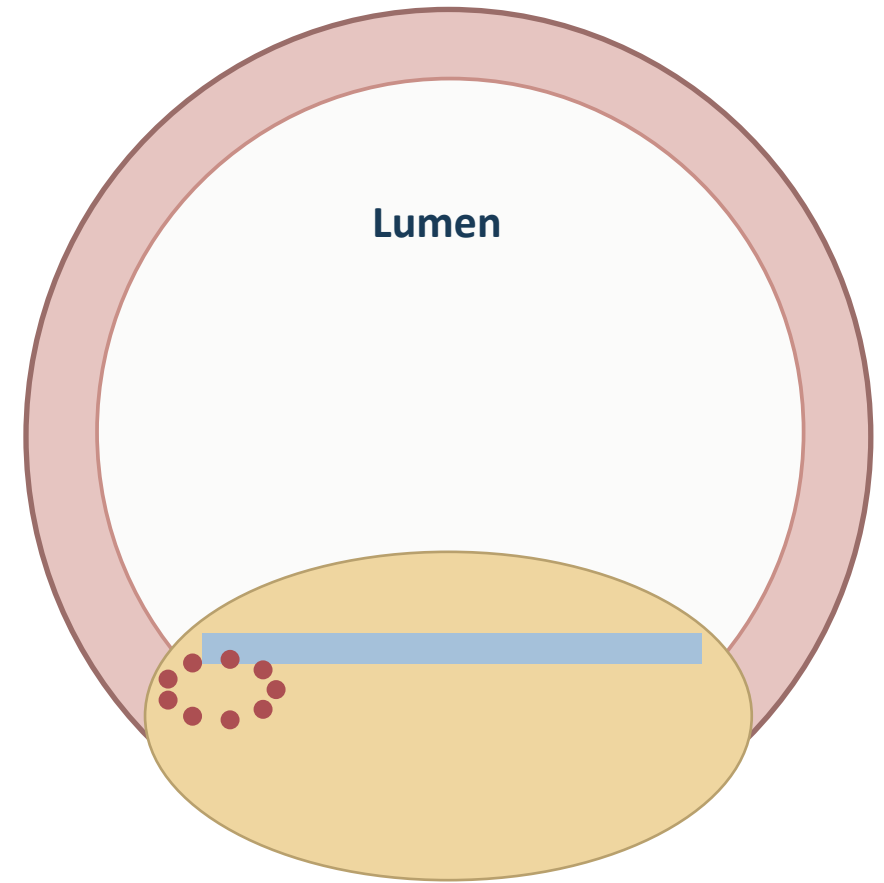
Cholesterol accumulation can amplify inflammation

- Cholesterol-rich deposits stimulate inflammatory responses in the plaque.
- Activated macrophages produce mediators that intensify local tissue injury.
- This inflammatory milieu can favor protease activity and cap destabilization.



The thin-cap, large-core combination matters

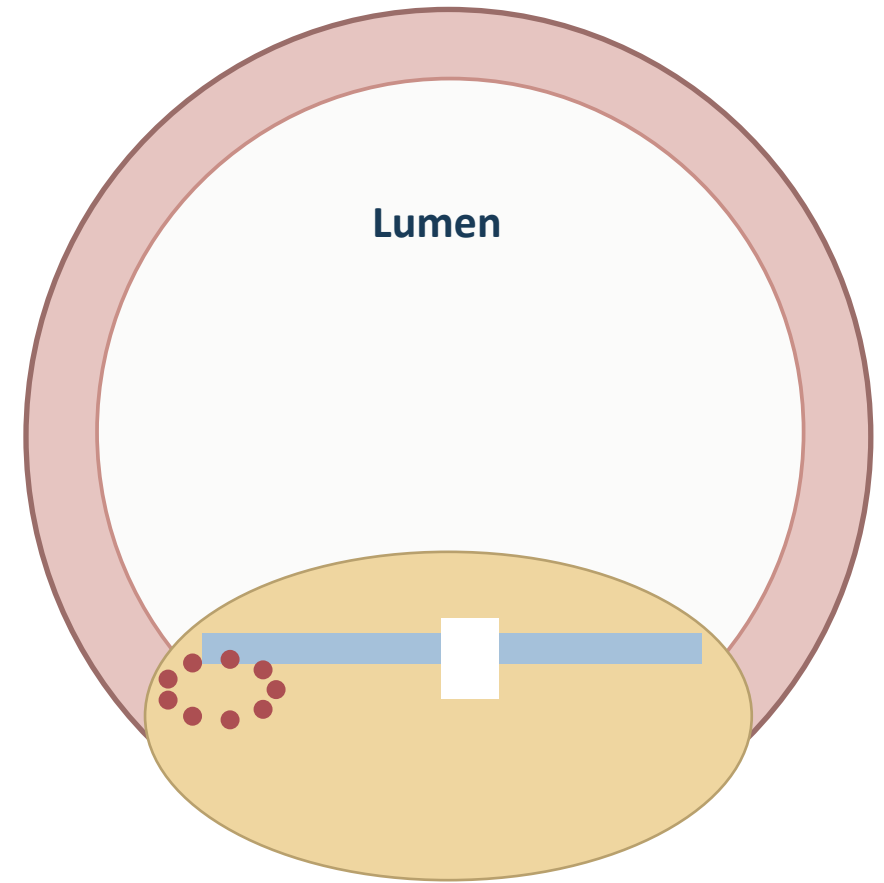
- A larger core provides little load-bearing support beneath the cap.
- A thin cap separates circulating blood from thrombogenic debris.
- Inflammatory infiltrates further reduce resistance to mechanical injury.



Thin cap — schematic

Inflammatory activity near the plaque shoulder

- The shoulder lies where the cap approaches adjacent relatively normal arterial wall.
- Macrophages and T lymphocytes can be concentrated in these cellular regions.
- Local proteolysis and mechanical stress make the cap–wall junction a potential failure site.



Thin cap — schematic

Rupture reflects stress exceeding cap strength

- External mechanical forces impose load on plaque tissue.
- Intrinsic cap architecture determines how much loading is tolerated.
- Failure becomes likely when the applied stress surpasses local mechanical resistance.

PATHWAY 1

Stress imposed

Pressure, shear,
constriction

PATHWAY 2

Cap resistance

Collagen + cap thickness

Intrinsic and extrinsic determinants interact

- Intrinsic: Fibrous-cap thickness, necrotic core, inflammation, cellular composition.
- Extrinsic: Blood pressure, platelet reactivity, and local vasospasm.
- Neither anatomy nor systemic triggers alone fully explains every acute event.

Cap architecture

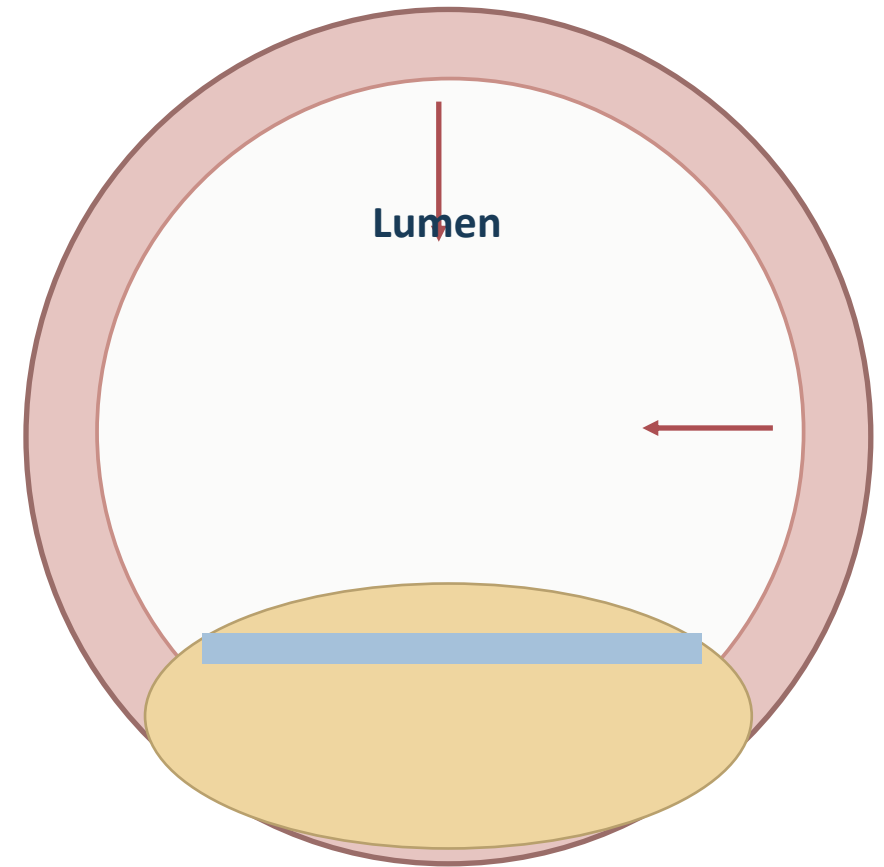
Plaque inflammation

Hemodynamic load

Platelet / vasomotor
state

Pressure and vascular forces load the plaque

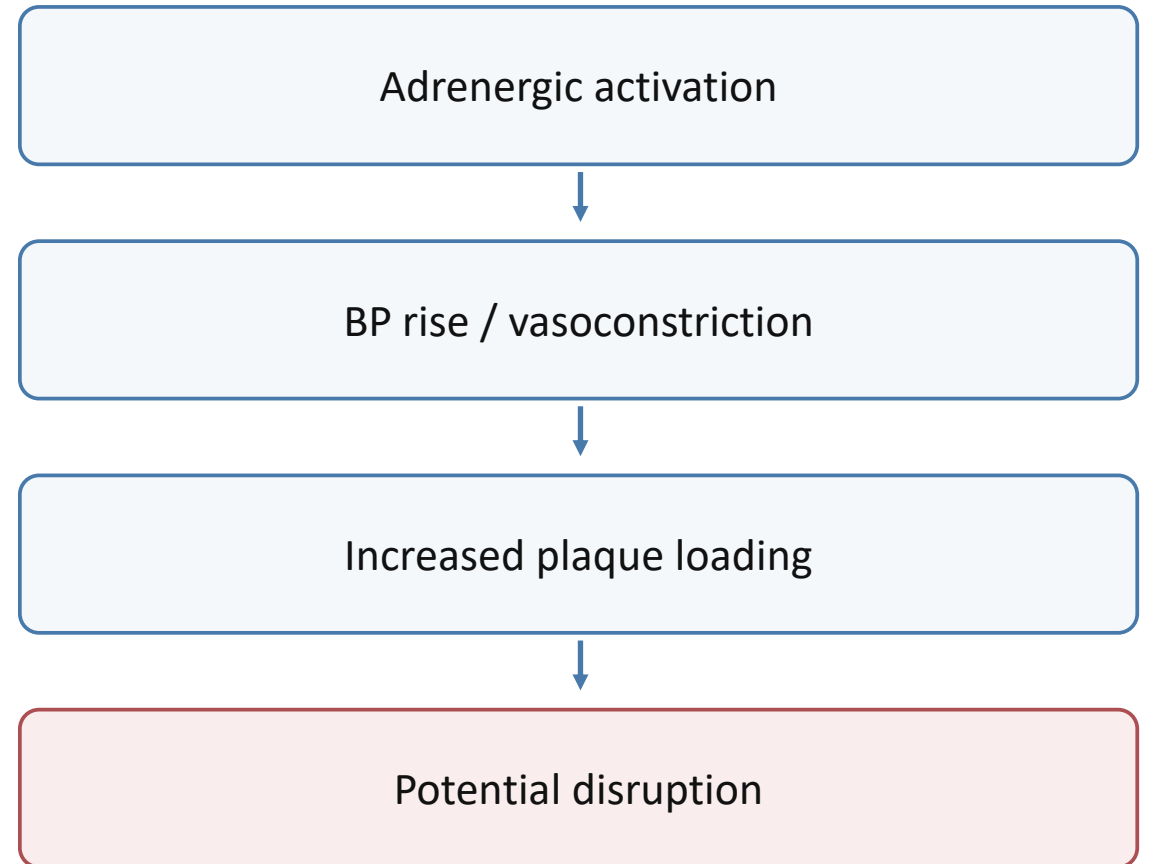
- Arterial pressure generates circumferential wall stress.
- Local flow and vessel geometry influence mechanical loading.
- A structurally fragile cap may fail under forces tolerated by a stronger plaque.



Fibrous cap — schematic

Adrenergic stimulation can increase plaque stress

- Sympathetic activation can raise systemic blood pressure.
- Adrenergic signaling can also increase local vasoconstriction.
- Both changes can raise mechanical forces at vulnerable sites.



Vasoconstriction has two adverse effects

- A narrowed functional lumen restricts residual blood flow.
- Contraction of the arterial wall may magnify local mechanical loading.
- At atheromatous sites, spasm can augment the effects of plaque change and thrombus.

PATHWAY 1

Vasoconstriction

Less available lumen

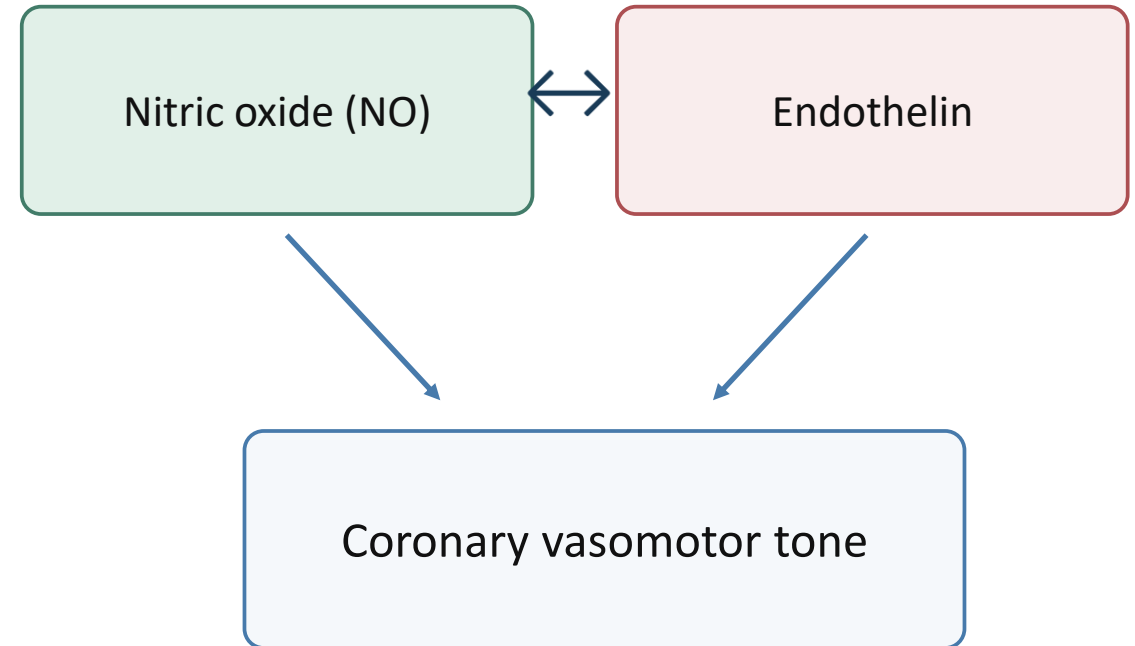
PATHWAY 2

Atherothrombosis

More obstruction + cap stress

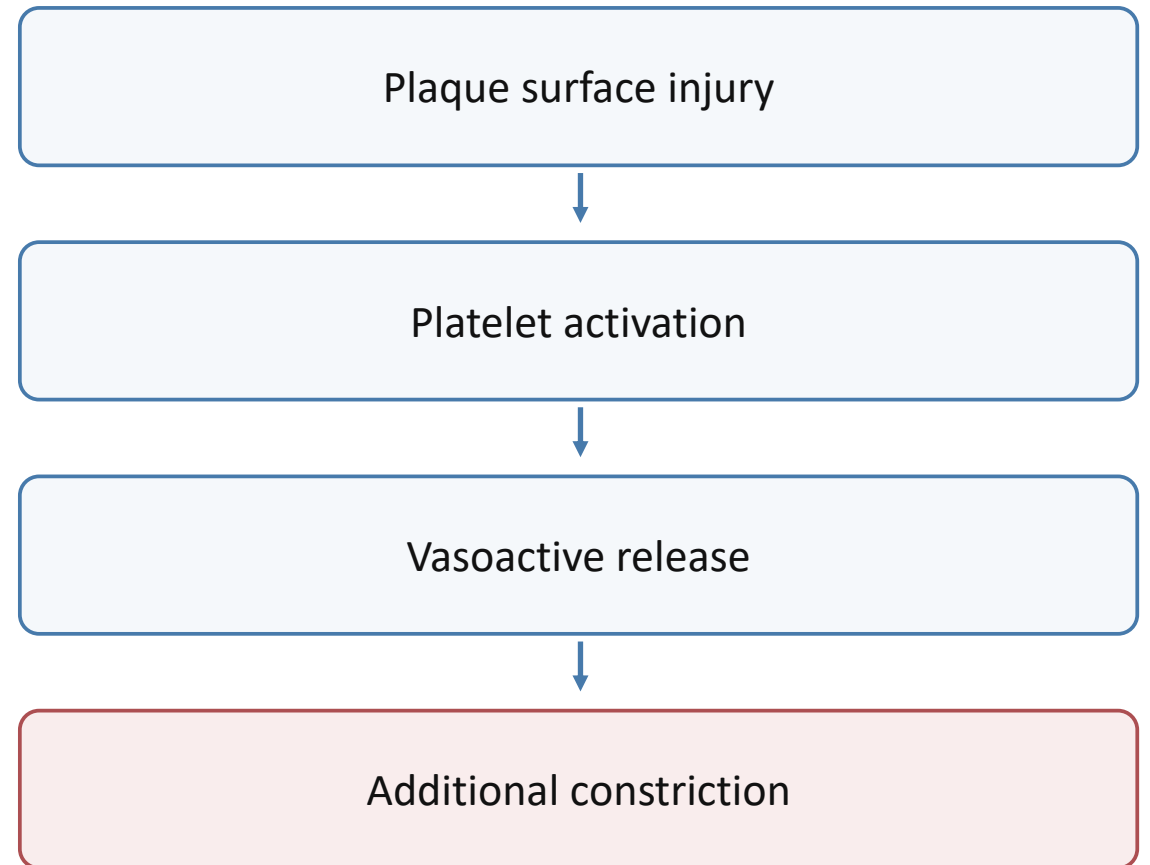
Endothelial dysfunction changes vasomotor balance

- Healthy endothelium produces nitric oxide, a vasodilator.
- Dysfunctional endothelium may shift the balance toward endothelin-mediated constriction.
- The resulting local vasomotor changes can intensify plaque-related obstruction.



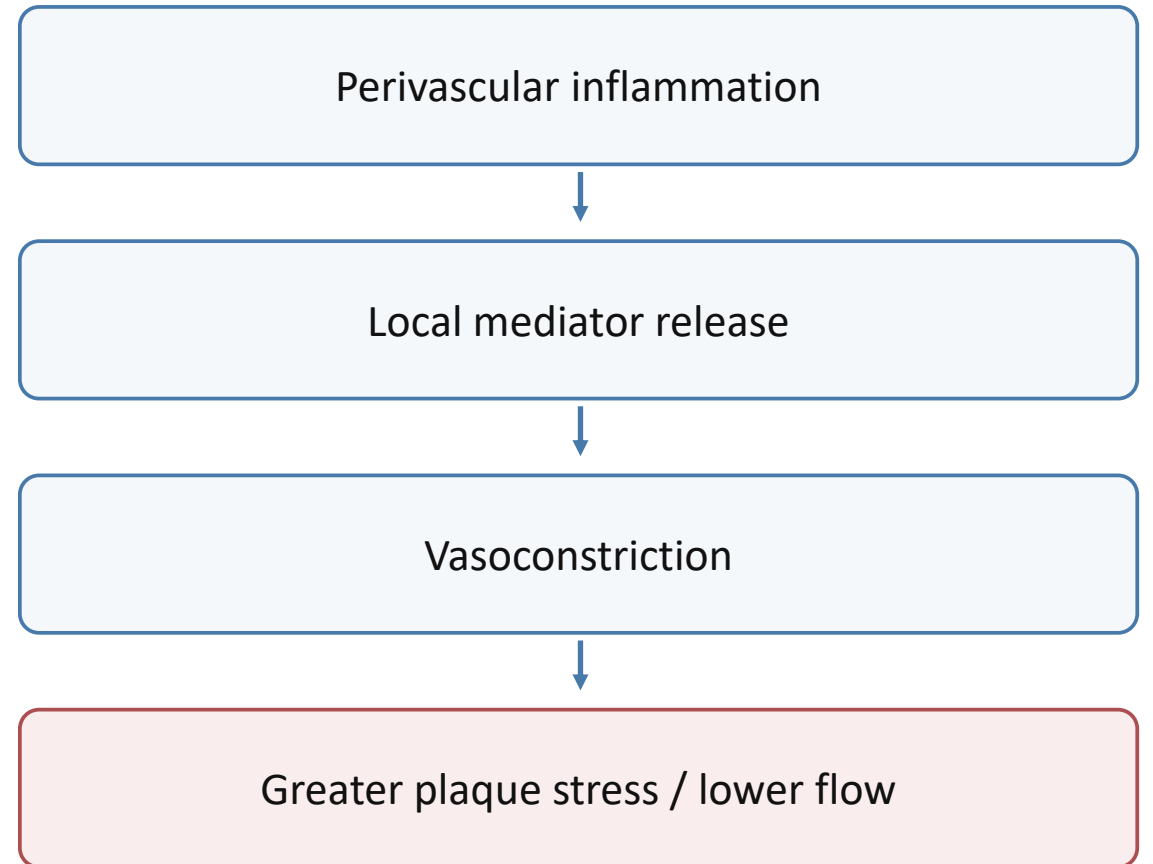
Activated platelets can intensify constriction

- Platelets adhere and activate at a disrupted surface.
- Locally released platelet contents include vasoconstrictive mediators.
- The combination of platelet accumulation and spasm promotes dynamic luminal compromise.



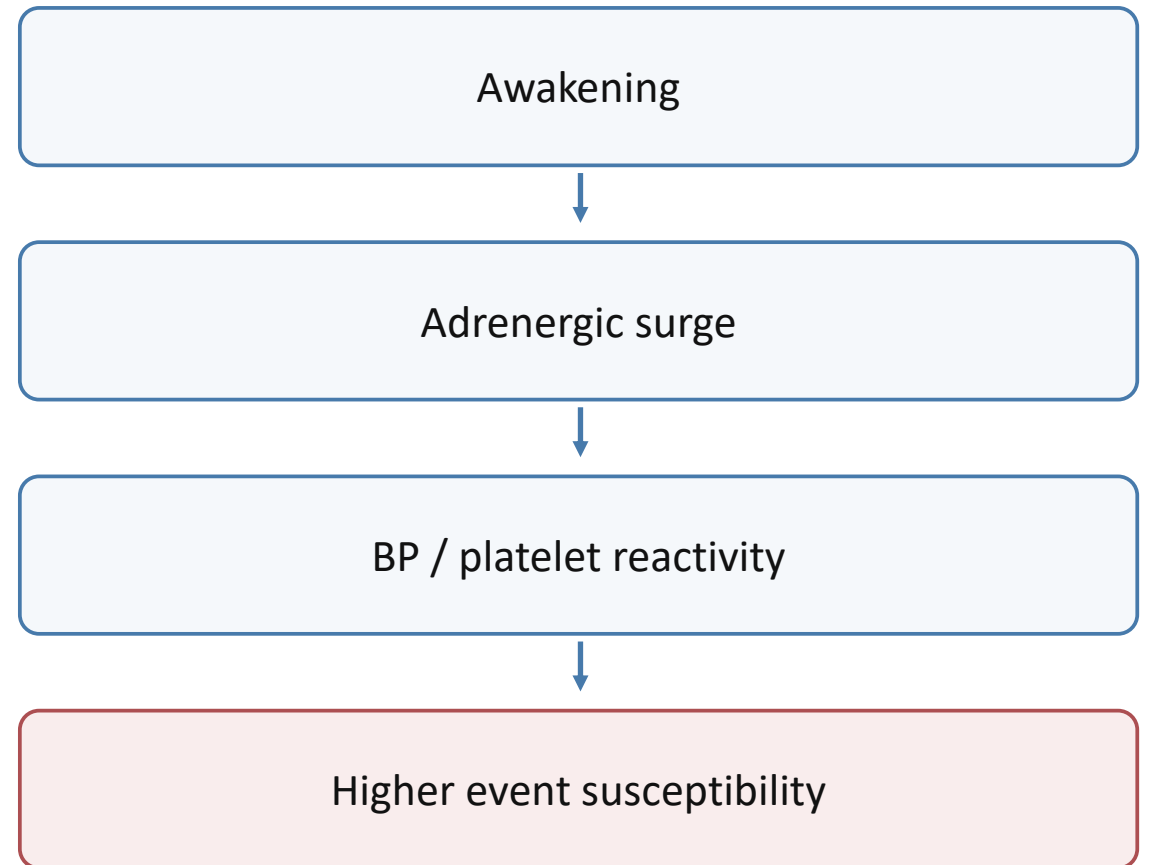
Perivascular inflammatory mediators can affect tone

- Inflammatory cells outside or around the vessel release vasoactive signals.
- These mediators can promote local vasoconstriction.
- Vasomotor tone is therefore influenced by vascular wall and adjacent tissue biology.



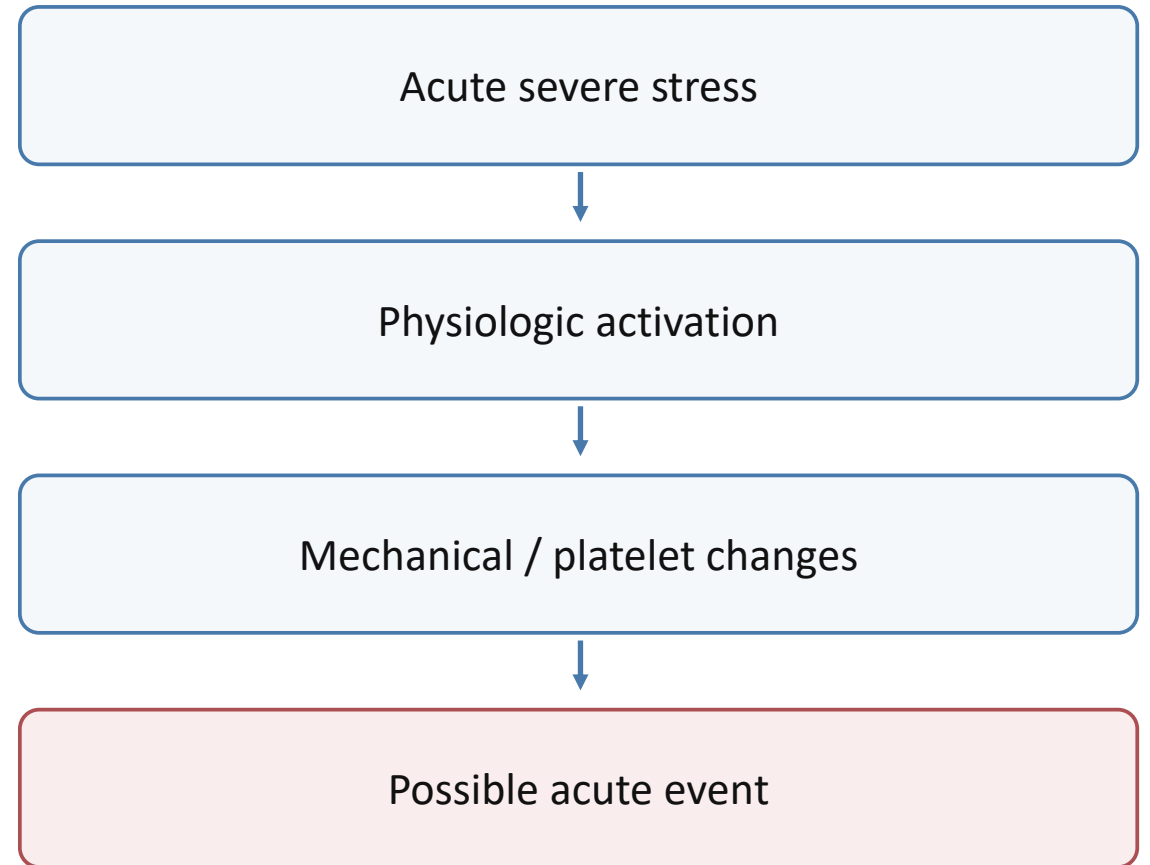
Morning sympathetic changes and event timing

- A morning increase in acute myocardial infarction occurrence.
- On awakening, blood pressure spikes can be followed by greater platelet reactivity.
- This observation illustrates time-varying extrinsic triggers rather than a fixed daily certainty.



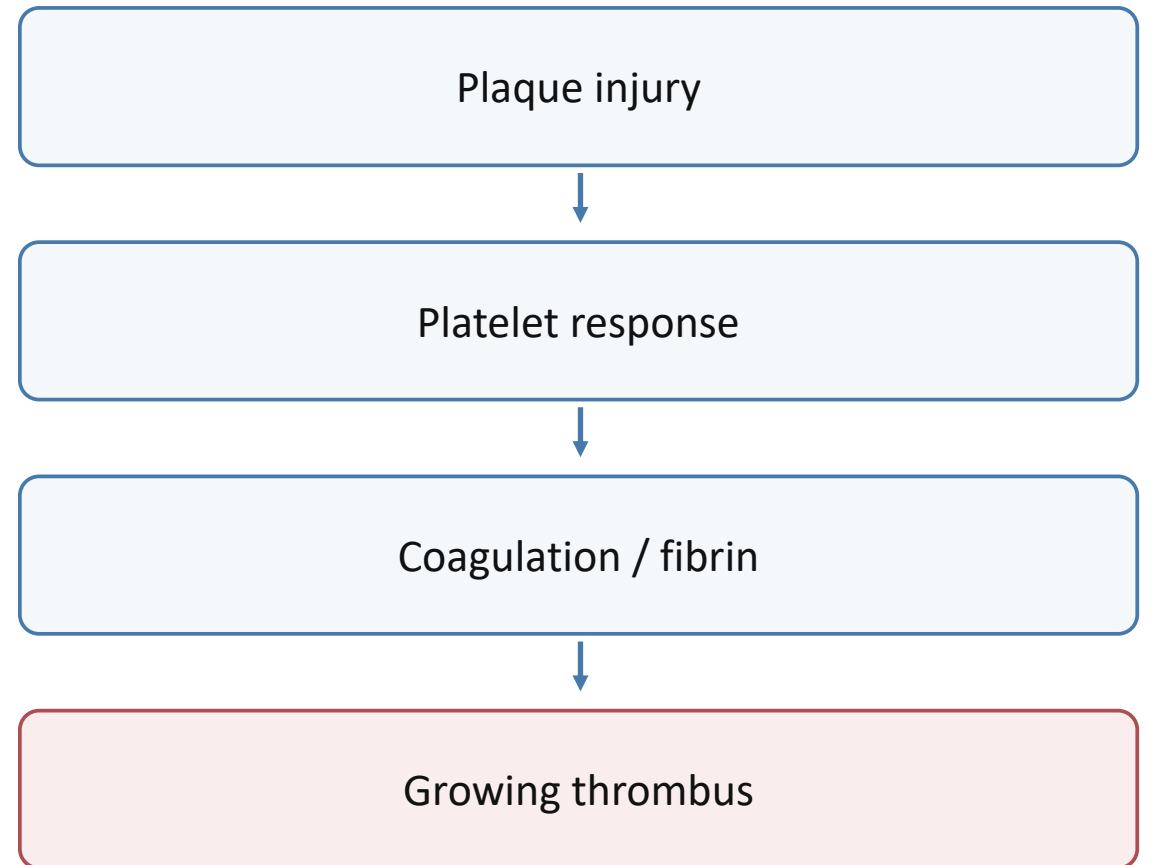
Intense emotional stress may precipitate events

- Severe stress can stimulate adrenergic and hemodynamic responses.
- The source notes increased sudden-death events during major disasters.
- A triggering circumstance interacts with a pre-existing susceptible vascular lesion.



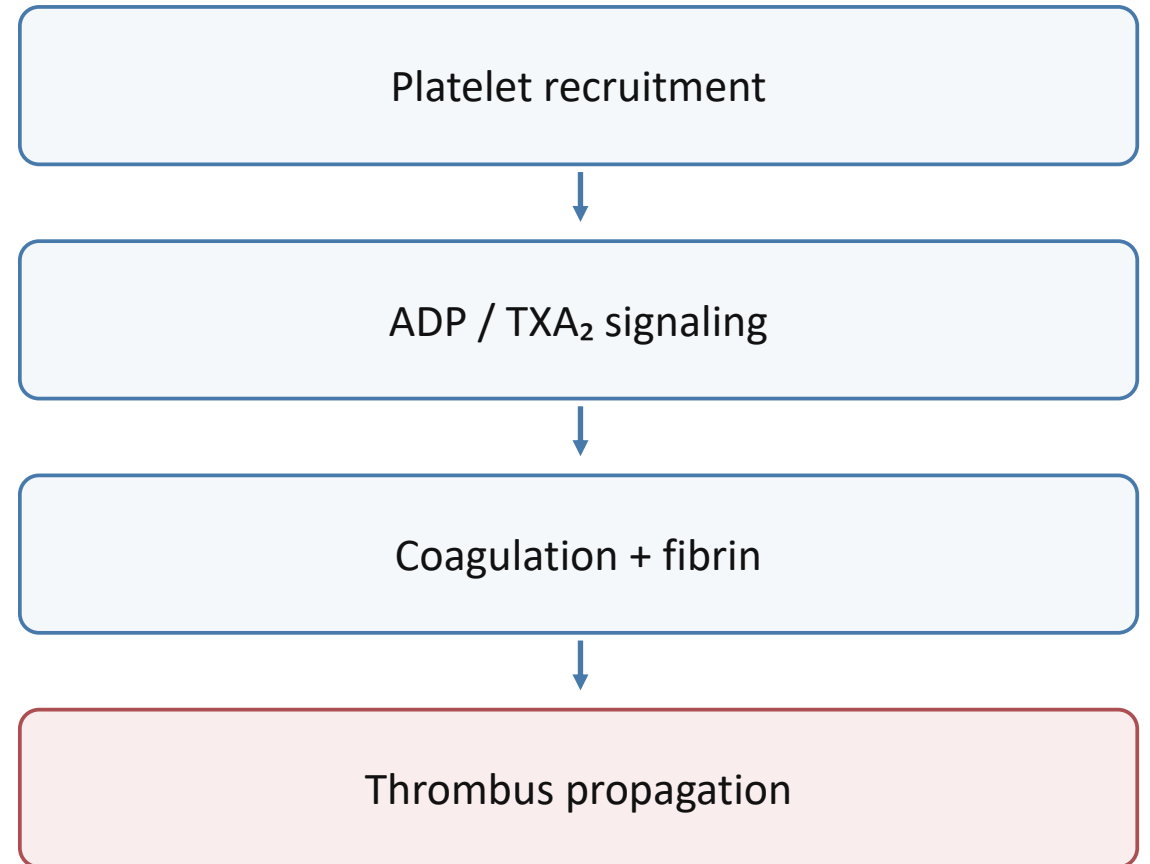
Rupture initiates a linked platelet–coagulation response

- Exposed matrix and plaque contents support platelet adhesion and activation.
- Coagulation adds fibrin to the developing thrombus.
- Accumulation can rapidly reduce the perfused luminal area.



Platelets and coagulation drive thrombus propagation

- Platelet-derived ADP and thromboxane A₂ recruit and activate more platelets.
- Tissue factor–associated coagulation amplifies fibrin generation.
- These processes reinforce one another at a thrombogenic plaque site.



Thrombotic obstruction is a spectrum

- A small mural thrombus may leave much of the lumen patent.
- A subtotal thrombus can cause marked, sometimes fluctuating ischemia.
- Complete occlusion can abruptly terminate downstream arterial perfusion.

Mural / nonocclusive



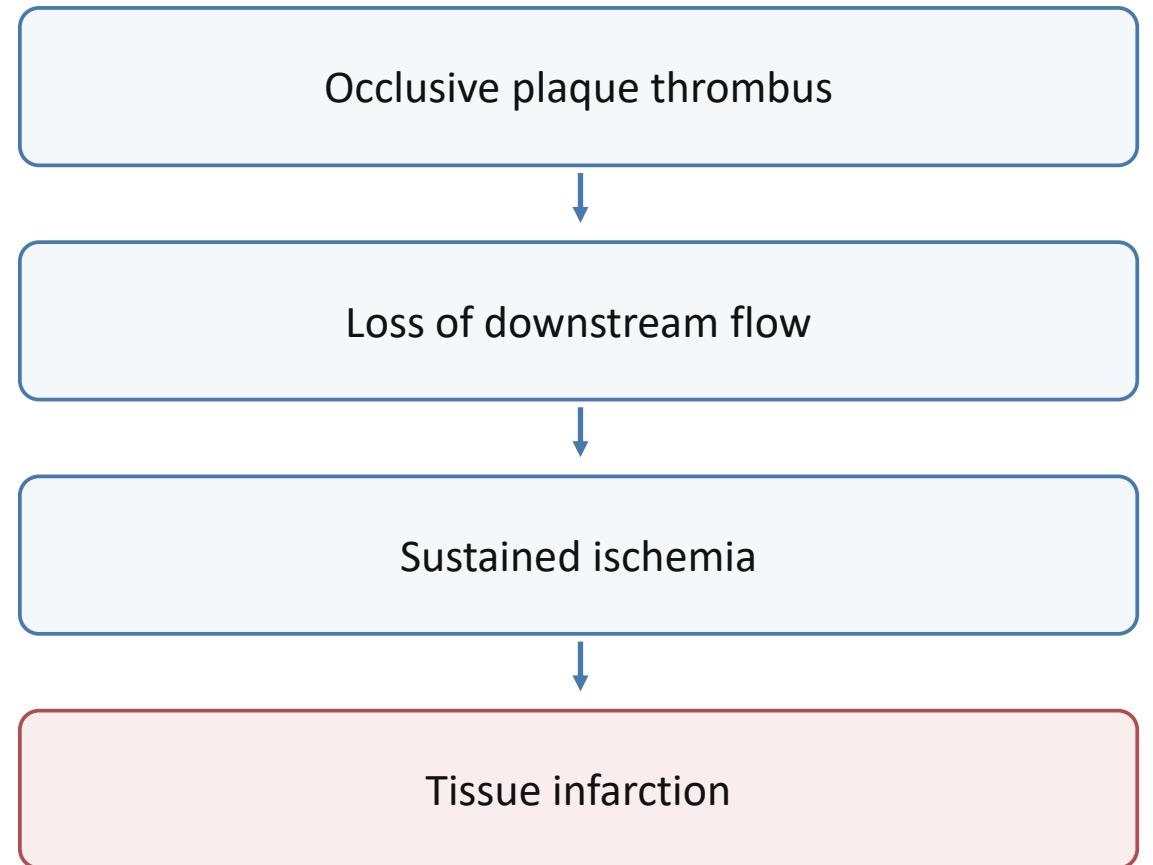
Subtotal obstruction



Complete occlusion

Complete occlusion can produce acute infarction

- A completely obstructed coronary artery can cause myocardial necrosis.
- Analogous thrombosis in relevant cerebral arteries can cause brain infarction.
- Tissue outcome depends on vascular territory, collateral flow, and duration of reduced perfusion.



Incomplete obstruction may still be clinically serious

- Mural or partially occlusive thrombi compromise flow without total closure.
- Thrombus size may change as deposition and removal fluctuate.
- Clinical consequences range from unstable ischemia to infarction, depending on the setting.

PATHWAY 1

Partly patent lumen

Variable perfusion

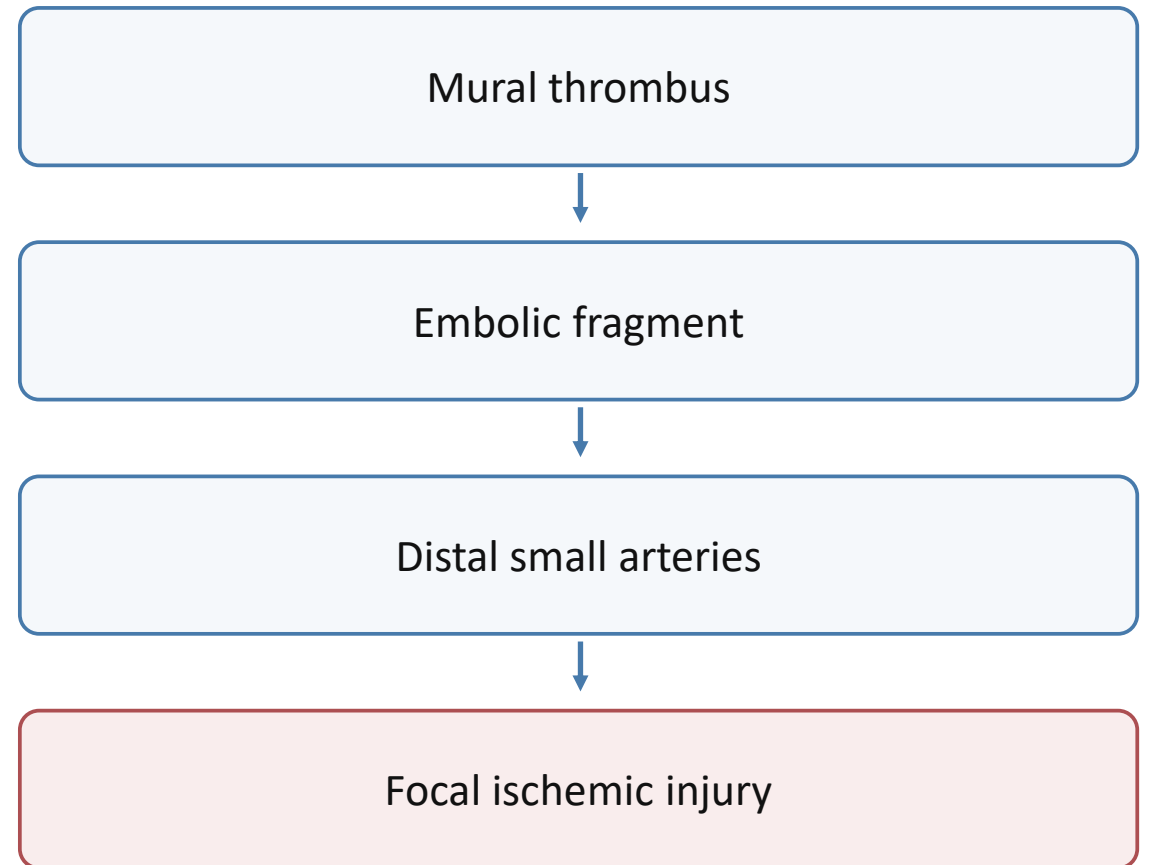
PATHWAY 2

Occluded lumen

Critical flow interruption

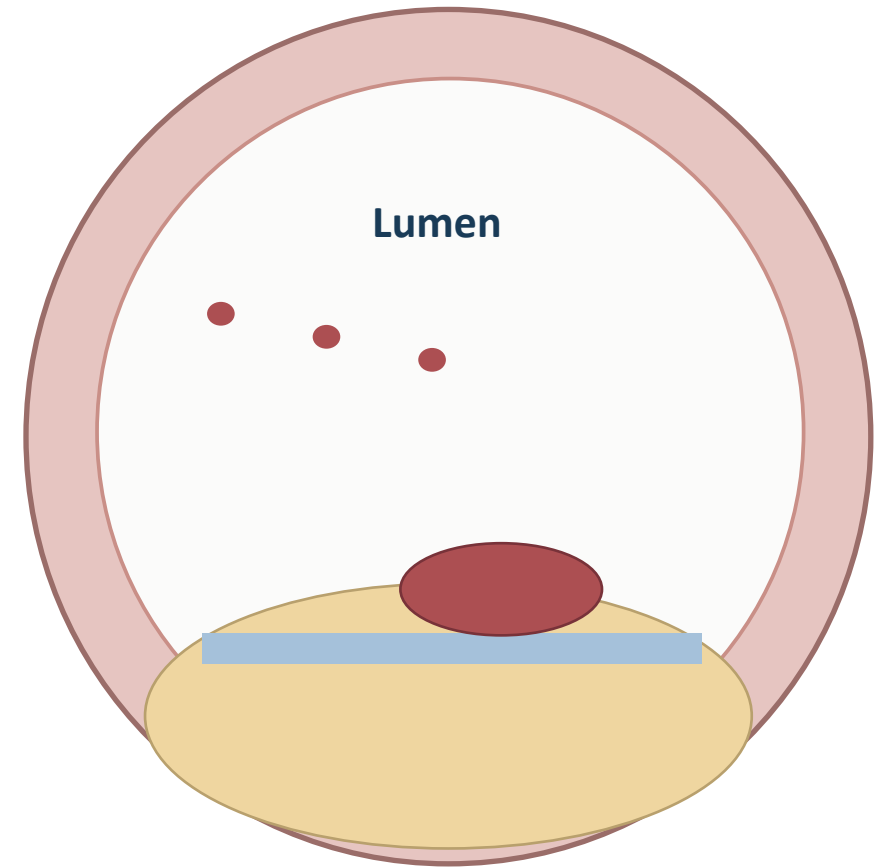
A coronary thrombus can embolize distally

- Part of a mural thrombus may detach and travel downstream.
- Smaller arterial branches and intramyocardial vessels can trap fragments.
- Distal obstruction adds focal injury beyond the original plaque location.



Distal microemboli may produce microinfarcts

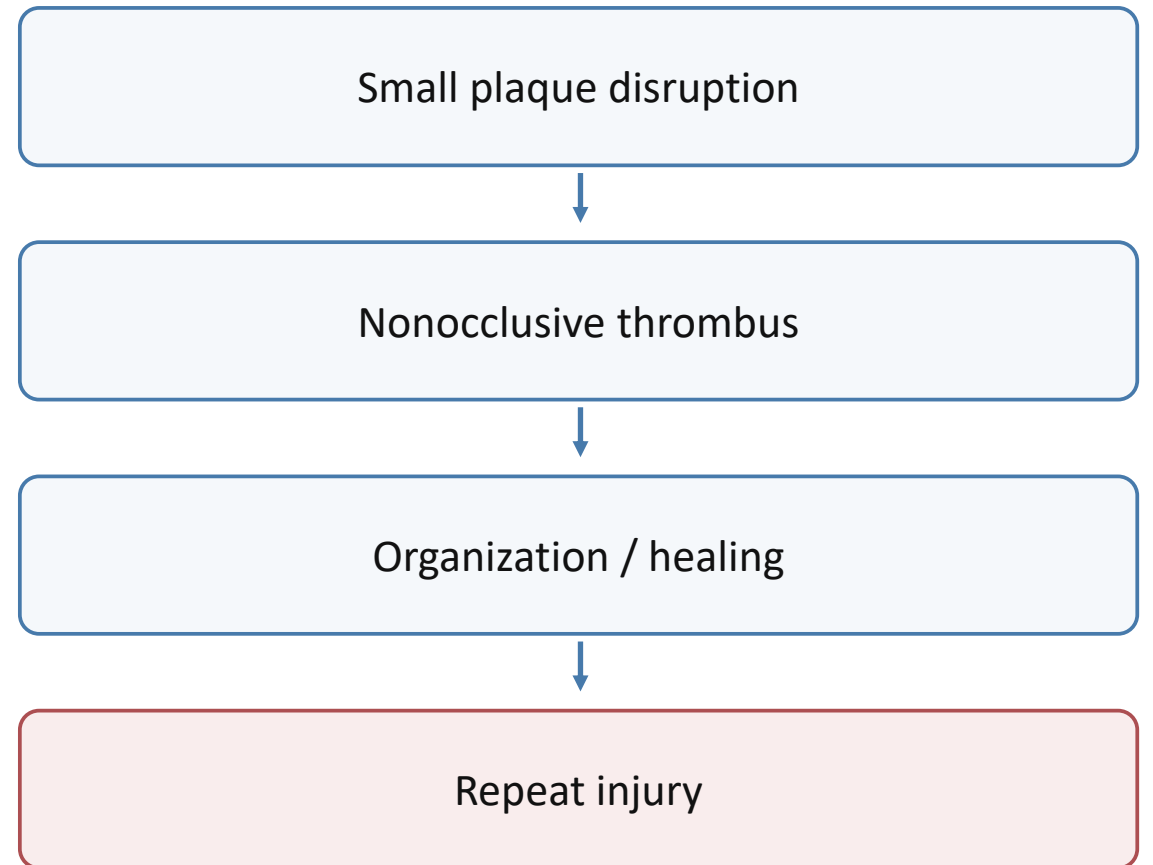
- Autopsy studies cited by the textbook show small coronary thromboemboli in sudden-death cases.
- Fragments may be found in the distal intramyocardial circulation.
- Associated microinfarcts support an embolic mechanism of myocardial injury.



Fibrous cap — schematic

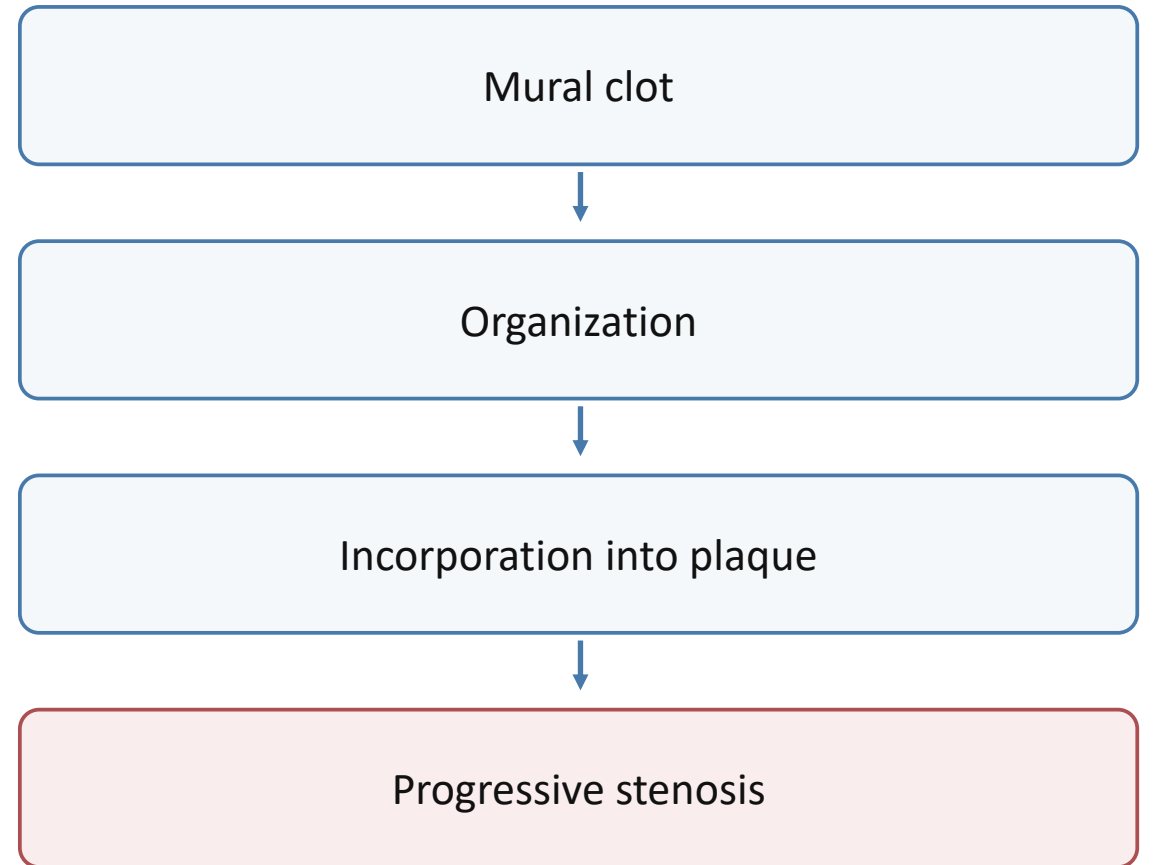
Subclinical plaque disruption may recur

- Not every ruptured plaque becomes completely occlusive.
- Superficial platelet deposition and thrombosis may produce no recognizable symptoms.
- Repeated episodes can change plaque composition over time.



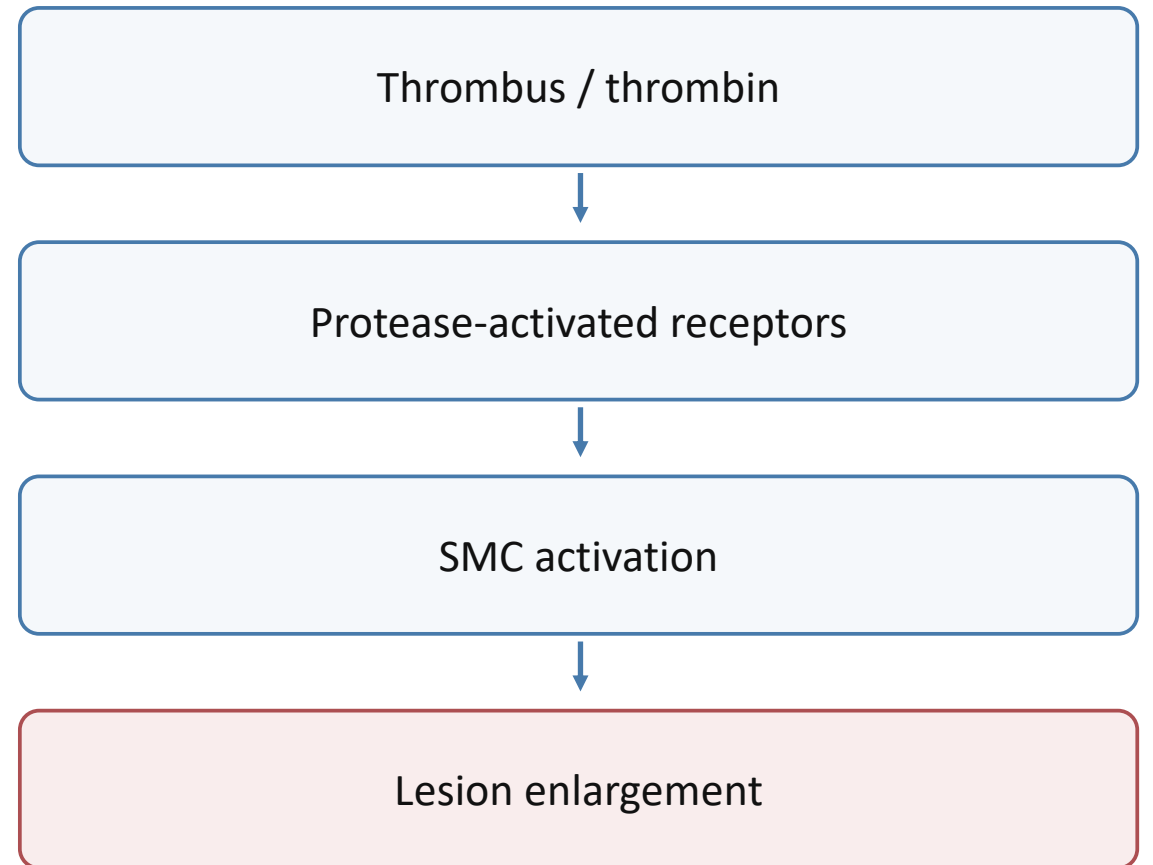
Organized thrombus contributes to plaque enlargement

- Healing converts superficial thrombus into incorporated tissue.
- Successive silent disruptions can gradually increase lesion mass.
- Thus thrombosis can promote both acute occlusion and chronic plaque progression.



Thrombin can stimulate intimal smooth muscle cells

- Thrombin is a coagulation protease, not only a clot-forming factor.
- Activation of protease-activated receptors on SMCs supports lesion growth responses.
- The coagulation response can therefore remodel plaque biology after the acute episode.



Flow restriction can result from several simultaneous forces

- Fixed plaque volume reduces the resting luminal area.
- Acute thrombus further occupies the lumen.
- Superimposed vasospasm can transiently worsen the residual flow pathway.

Fixed atheroma

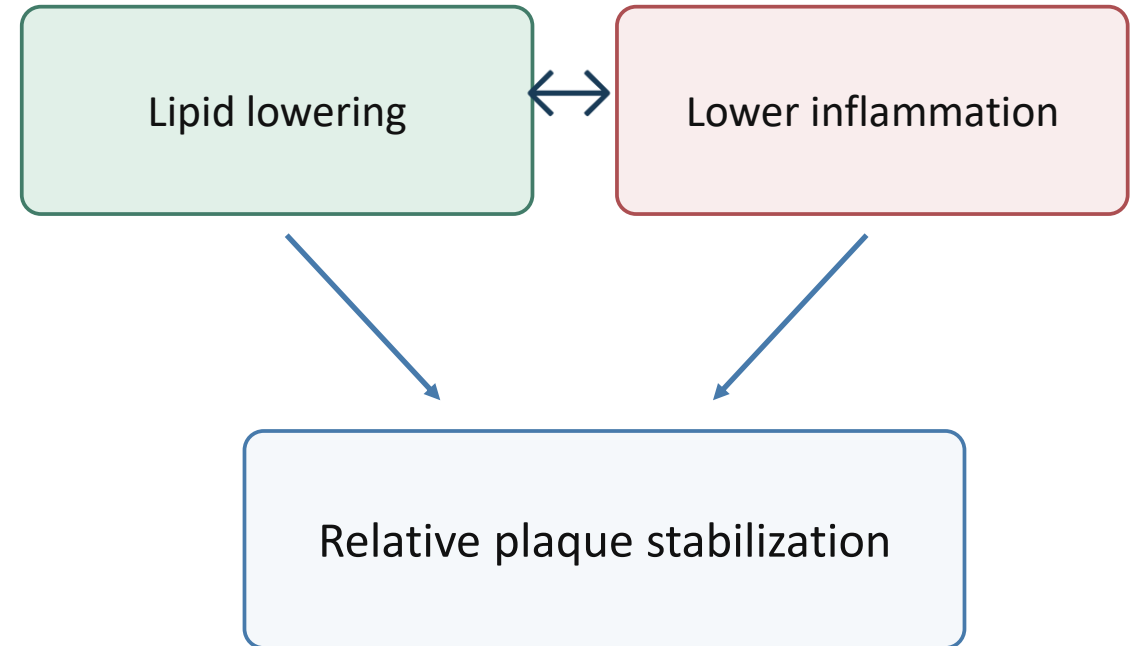
Superimposed thrombus

Vasoconstriction

Downstream ischemia

Plaque stabilization modifies biology, not just size

- Statins reduce circulating atherogenic cholesterol.
- The textbook also notes reduced plaque inflammation as a stabilizing action.
- Greater cap stability can lower vulnerability even when anatomic regression is modest.



Classify an acute complication by its primary lesion

- When the cap opens into the core, describe rupture or fissuring.
- When the luminal endothelial covering is lost without cap rupture, describe erosion.
- When blood accumulates within the lesion, describe intraplaque hemorrhage.

Finding / insult	Process	Immediate effect
Cap breach to core	Rupture	Thrombogenic contents exposed
Surface denudation	Erosion	Subendothelial interface exposed
Blood within lesion	Hemorrhage	Expanded plaque volume

Case discussion: Infarction despite modest prior stenosis

- A person without antecedent angina develops an acute coronary event.
- Prior lumen imaging showed only mild-to-moderate fixed disease.
- Mechanistic explanation: A susceptible plaque may have disrupted, followed by thrombosis.

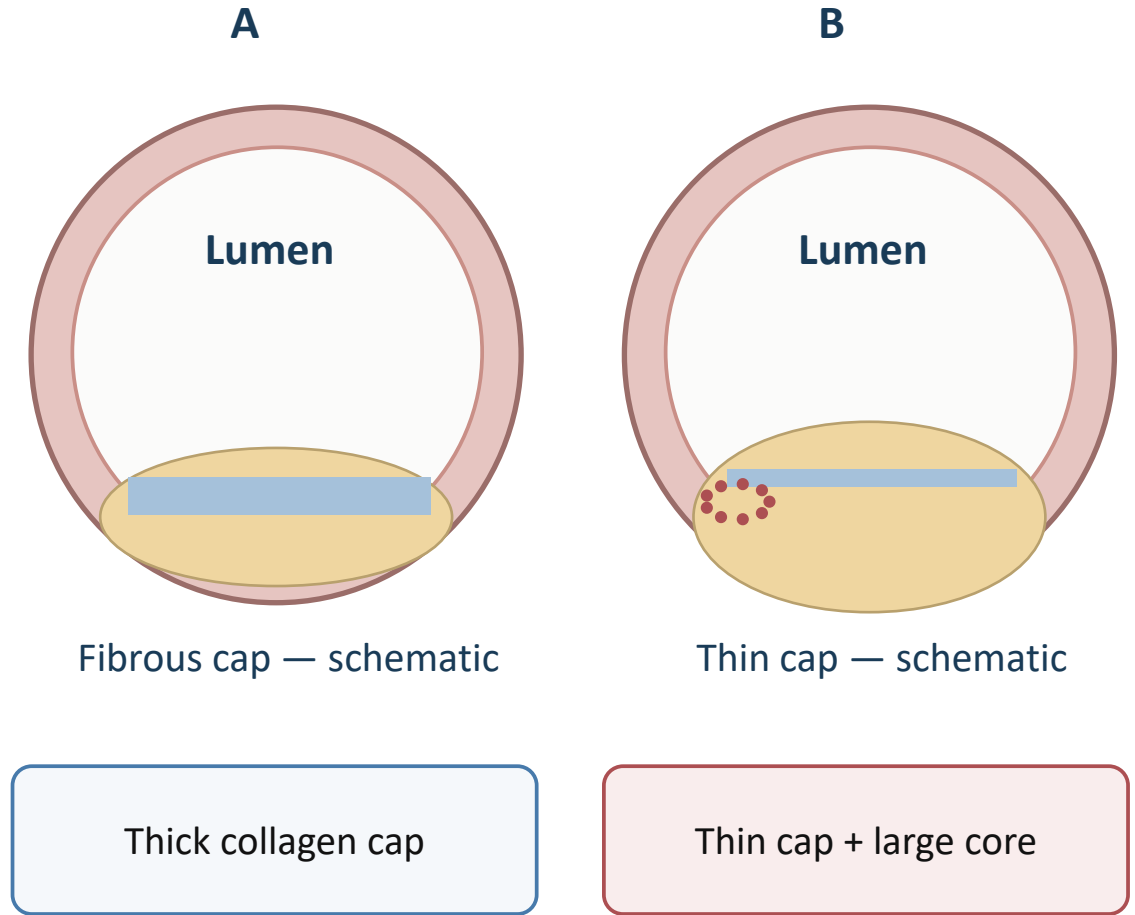
Why can a noncritical stenosis become an acute culprit?



Surface change + superimposed thrombus

Case discussion: Two plaques with similar lumen size

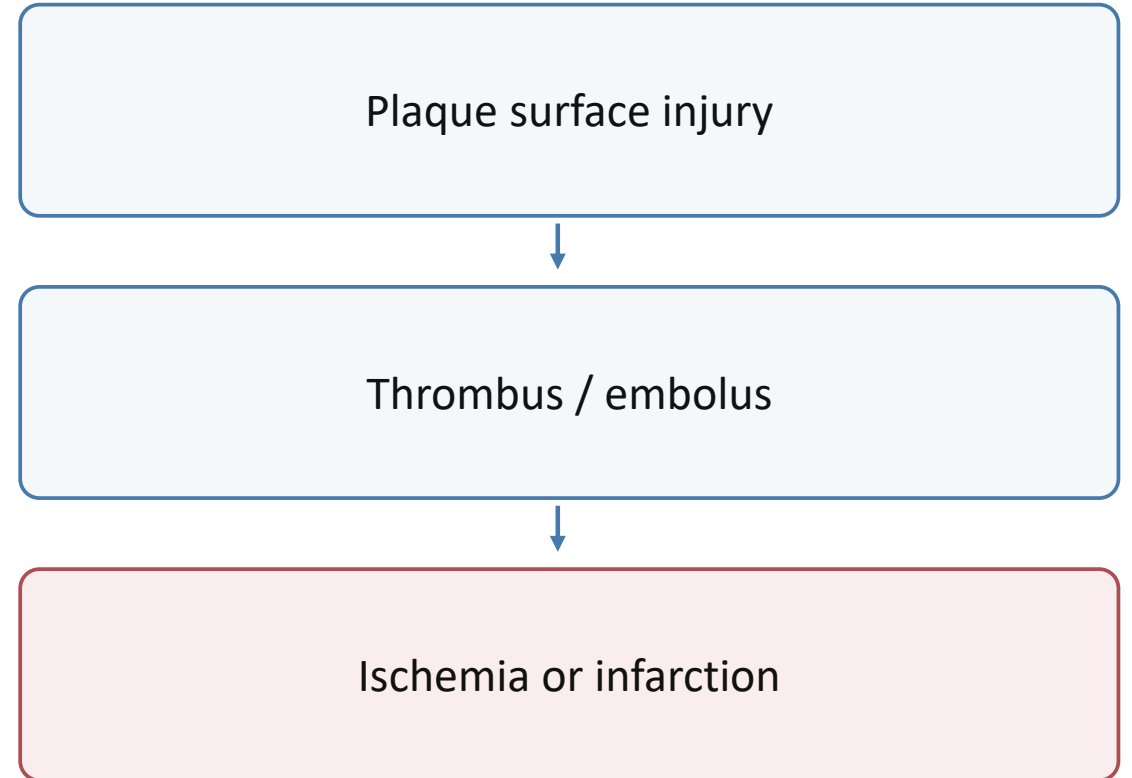
- Plaque A has a thick collagen-rich cap and few inflammatory cells.
- Plaque B has a thin cap, larger necrotic core, and abundant macrophages.
- Plaque B has more structural features associated with acute rupture.



Schematic cross-sections

Mechanistic synthesis: Injury, thrombus, outcome

- Rupture and erosion can rapidly initiate luminal thrombosis.
- Hemorrhage can expand and destabilize the plaque from within.
- Resulting clinical consequences depend on thrombus extent, distal embolization, vasospasm, and tissue perfusion.



Five clinicopathologic conclusions

- Culprit lesions need not be critically stenotic beforehand.
- Cap thickness and collagen turnover are central determinants of rupture susceptibility.
- Plaque inflammation can weaken matrix through altered synthesis and degradation.
- Extrinsic pressure, platelet, and vasomotor changes can trigger events.
- Silent thrombus organization is a mechanism of later plaque growth.

Principal reading and image policy

- Robbins, Cotran & Kumar. Pathologic Basis of Disease. 11th ed. 2026. Chapter 11, “Blood Vessels,” pp. 455–458.
- Related coronary pathophysiology: Chapter 12, “The Heart,” pp. 493–495.
- Vascular illustrations in this lecture are original editable schematics, not diagnostic photomicrographs.