

Angina Pectoris

Transient myocardial ischemia: coronary pathology and clinical phenotypes

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Learning objectives

- Explain why transient myocardial ischemia produces anginal symptoms without myocyte necrosis.
- Relate coronary stenosis, plaque change, and arterial spasm to the three angina patterns.
- Distinguish stable, variant, unstable, and silent ischemic presentations.
- Apply clinicopathologic mechanisms to focused clinical vignettes.

Angina within ischemic heart disease

Myocardial oxygen supply–
demand imbalance



Transient ischemia



Anginal syndrome

Ischemic heart disease also includes myocardial infarction and chronic ischemic syndromes.

The defining lesion in angina is functional ischemia, not established necrosis.

Angina: A clinicopathologic definition

Recurrent, paroxysmal substernal or precordial discomfort

- Episodes reflect transient myocardial ischemia.
- Duration in the text: Approximately 15 seconds to 15 minutes.
- Ischemia is insufficient to cause myocyte necrosis.

Ischemia is not synonymous with infarction

Angina pectoris

Transient oxygen inadequacy

No myocyte necrosis by definition

Recurrent episodes can resolve

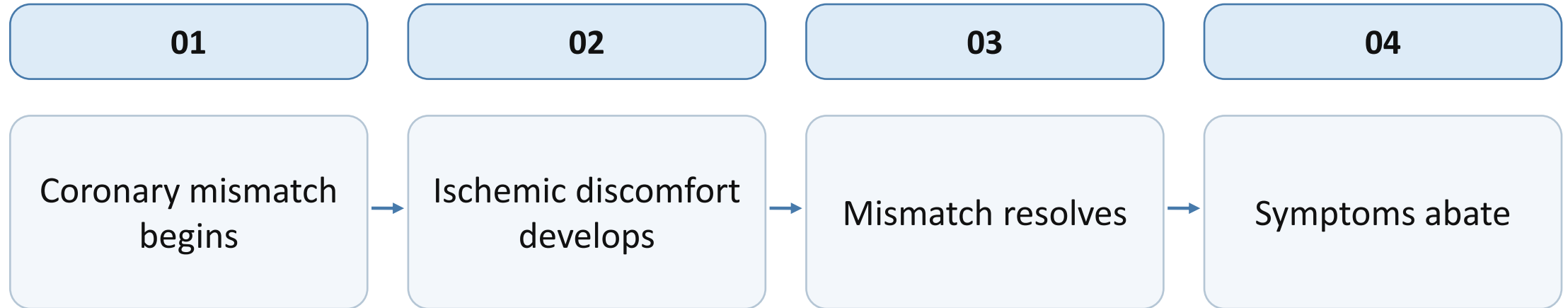
Myocardial infarction

Prolonged ischemic injury

Cardiomyocyte death occurs

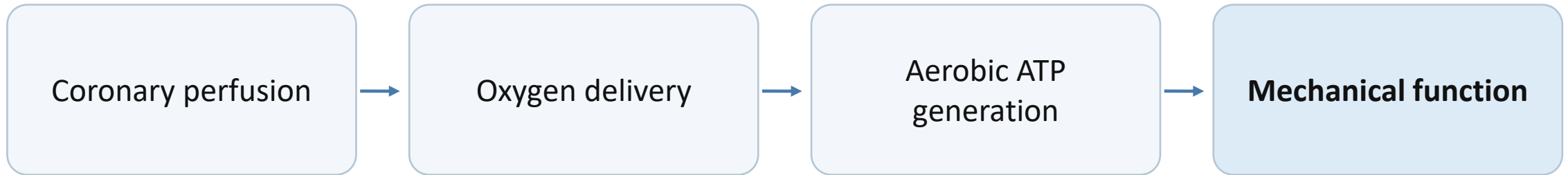
Irreversible tissue injury develops

Transient ischemia as an episode



Conceptual sequence; The timing and severity vary between episodes.

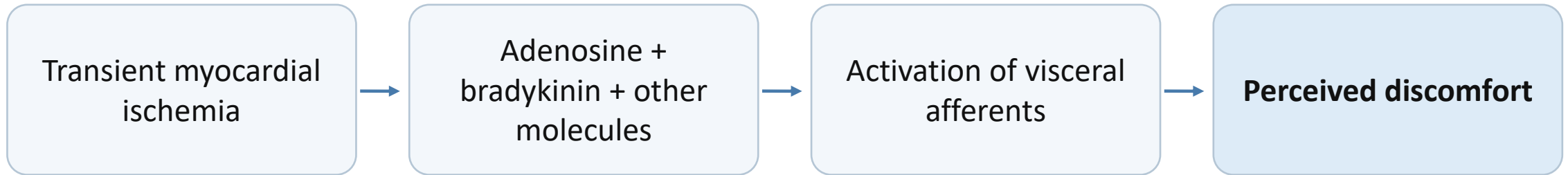
Why myocardial perfusion matters



Myocardium depends on an uninterrupted oxygen supply.

A supply–demand mismatch is the central mechanism of ischemic heart disease.

Anginal pain: Biochemical mediators



Adenosine and bradykinin as examples of ischemia-induced mediators.

Autonomic afferents transmit the signal

- Ischemic metabolites activate sympathetic and vagal afferent nerves.
- The sensory signal is generated by viable, ischemic tissue.
- Perceived pain intensity does not directly measure myocyte necrosis.

Neural activation explains symptoms;
It is not evidence of infarction.

The characteristic pain phenotype

- Classically crushing or squeezing.
- Usually substernal; It may be described as precordial pressure.
- The episodic quality is an important clinical clue.

The pain description supports—but does not uniquely establish—
ischemia.

Referred pain from myocardial ischemia

Ischemic substernal discomfort

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graph TD; A[Ischemic substernal discomfort] --> B[Left arm]; A --> C[Left jaw];
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Left arm

Left jaw

These are classic referred-pain locations.

Silent ischemia challenges symptom-based reasoning

- Not all myocardial ischemic episodes are perceived as pain.
- Some patients have non-pain symptoms; Others have no symptoms.
- Absence of chest discomfort is not equivalent to absence of ischemia.

Symptoms and ischemia are related,
but not identical.

Symptoms of silent ischemia

Dyspnea

Breathlessness may replace chest pain.

Palpitations

An altered heartbeat may be noted.

Nausea / vomiting

Visceral symptoms can predominate.

Diaphoresis / fatigue

Autonomic or nonspecific manifestations.

Who may experience silent ischemia?

- Particularly common in older individuals.
- Also important in patients with diabetic neuropathy.
- Pain perception can be altered even when myocardial ischemia occurs.

An apparently “atypical” presentation may still reflect coronary disease.

Three overlapping patterns of angina

Stable

Fixed coronary disease +
increased demand

Variant

Episodic coronary spasm

Unstable

Acute plaque change ±
thrombus / spasm

That these patterns may overlap.

Oxygen supply versus myocardial demand

CORONARY SUPPLY

Coronary perfusion

Vascular lumen

Vasomotor tone

MYOCARDIAL DEMAND

Physical work

Emotional arousal

Psychological stress

Mismatch → ischemia

Ischemia develops when supply is inadequate for demand.

Mechanisms that reduce myocardial supply

Fixed narrowing

Atherosclerotic lumen
obstruction

Acute plaque change

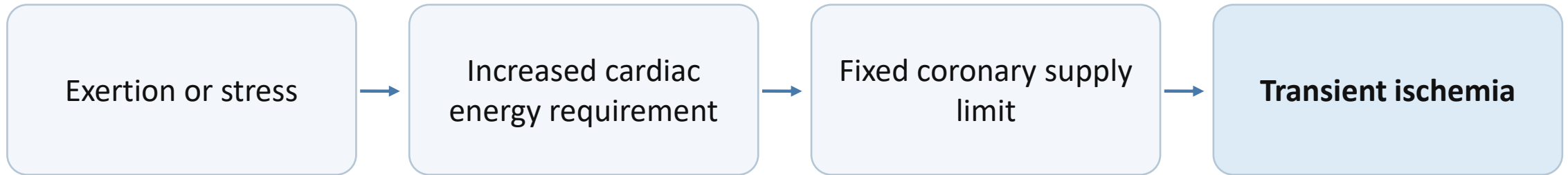
Thrombotic reduction of
perfusion

Vasospasm

Transient arterial
constriction

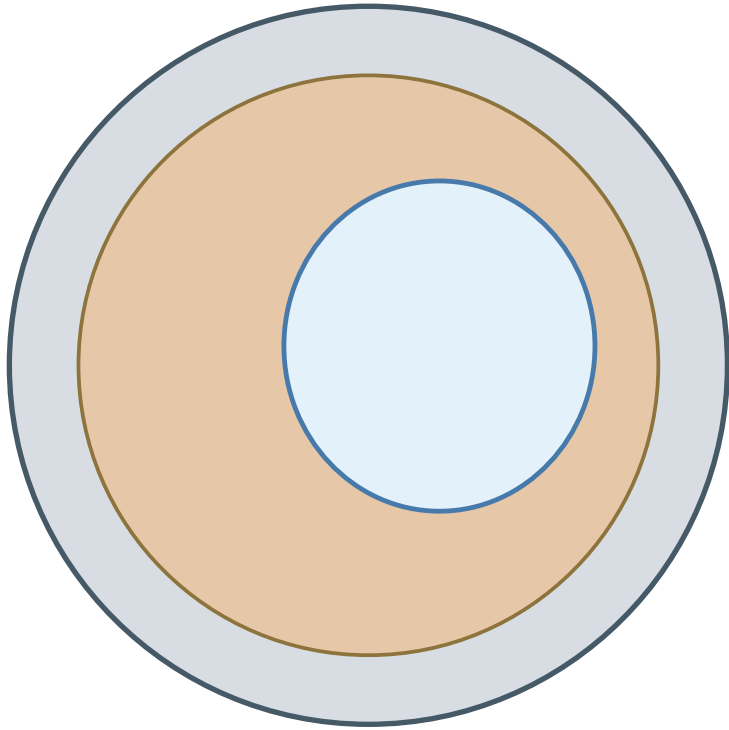
All can alter perfusion, but their clinical patterns differ.

Why demand can trigger angina



Stable angina is elicited when demand exceeds the attainable perfusion reserve.

Chronic coronary atherosclerosis



CORONARY ARTERY (CROSS-SECTION)

- Atherosclerotic plaques commonly involve epicardial coronary arteries.
- The plaque reduces usable luminal cross-sectional area.
- Chronic narrowing underlies the common stable-angina mechanism.

Coronary vasodilator reserve

Rising myocardial demand



Compensatory coronary
vasodilation

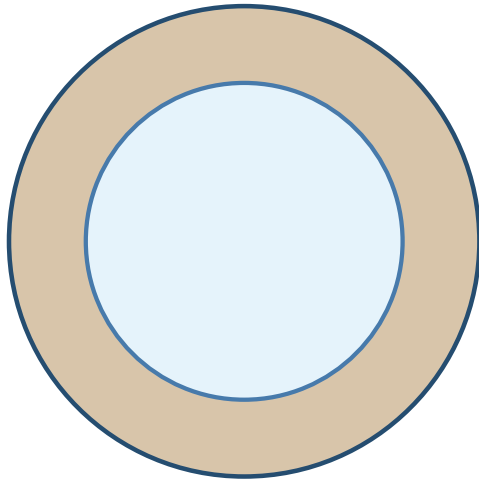


Additional blood delivery

With critical fixed stenosis, compensatory vasodilation cannot satisfy moderate extra demand.

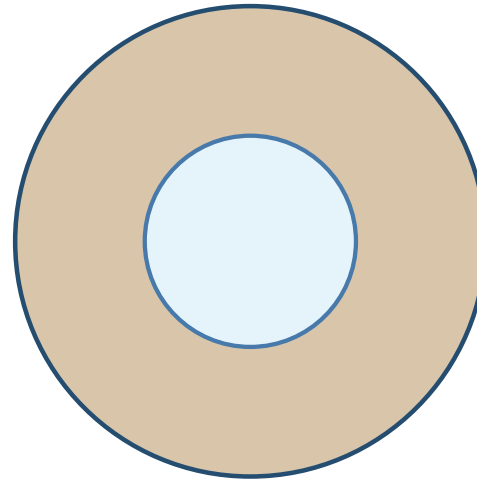
Functional flow reserve matters more than local anatomy alone.

Critical stenosis and exertional ischemia



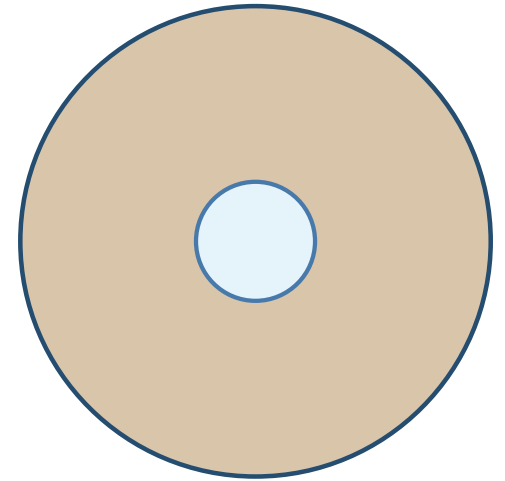
Unrestricted reserve

Mild or no limitation



>70% area obstruction

Often symptomatic on exertion

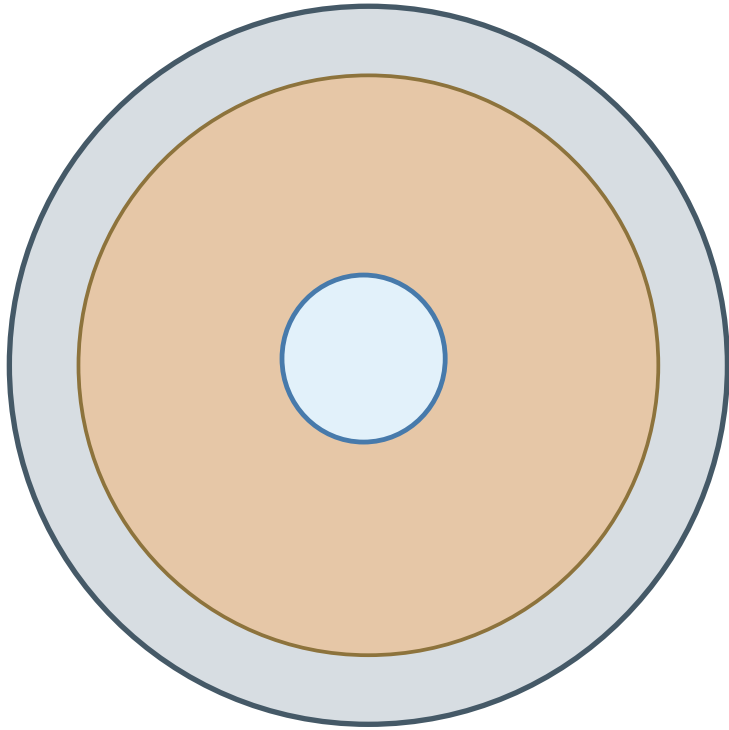


≈90% area obstruction

Perfusion may fail at rest

Textbook cross-sectional area descriptions; Conceptual and not a stand-alone clinical test.

Severe stenosis may compromise resting flow



CORONARY ARTERY (CROSS-SECTION)

- Approximately 90% luminal-area obstruction as a level that can reduce resting flow.
- Exertional and rest ischemia therefore reflect different degrees of reserve failure.
- Anatomic narrowing and symptoms are not perfectly interchangeable.

Which coronary arteries are affected?

LAD

Left anterior descending

LCX

Left circumflex

RCA

Right coronary artery

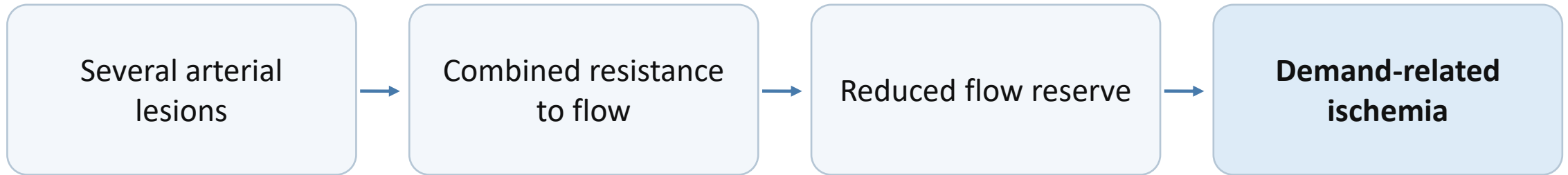
One, two, or all three epicardial vessels may have atherosclerosis.

Proximal coronary distribution

- Clinically important plaques often occur in the first several centimeters of the LAD or LCX.
- Major branches can also be involved.
- Penetrating intramyocardial branch atherosclerosis is described as uncommon.

Angina frequently reflects epicardial coronary disease.

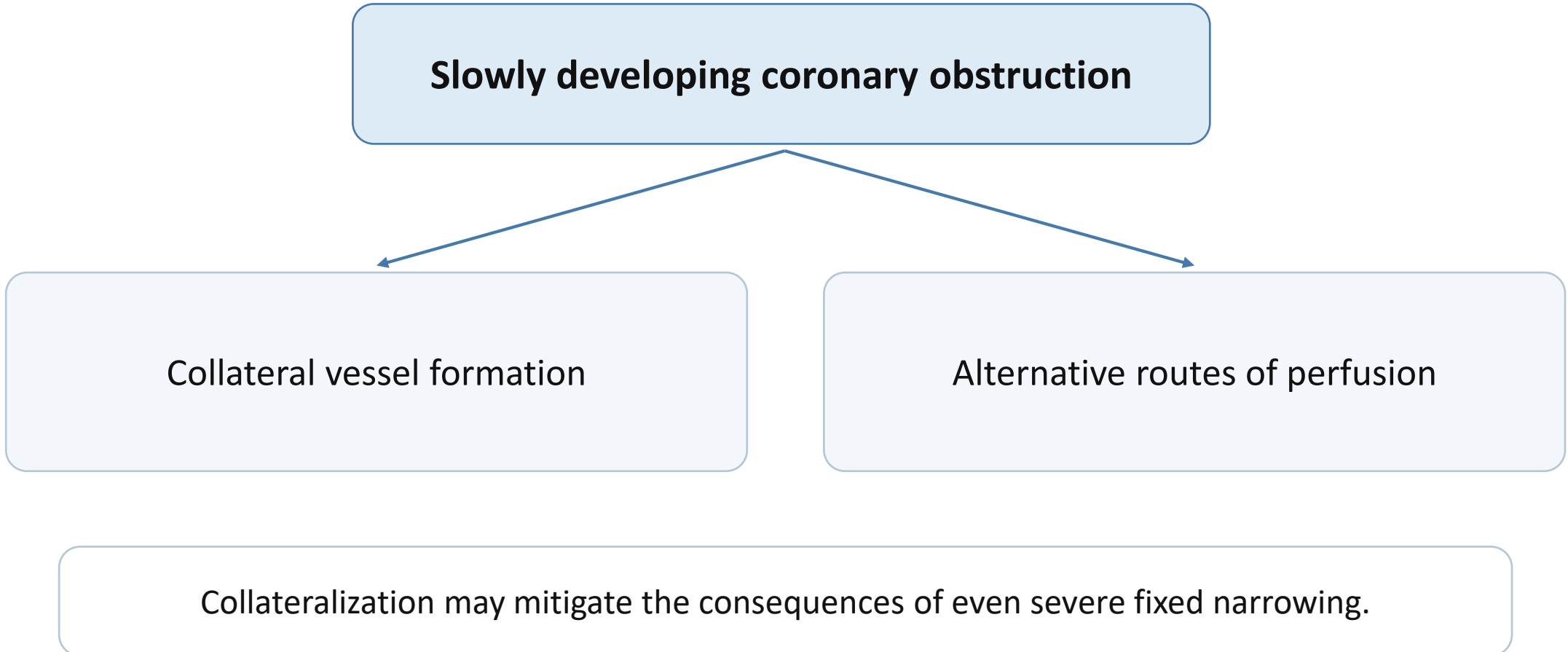
Multivessel stenosis and functional severity



Multiple lesions may affect perfusion even when no one narrowing tells the entire story.

Collateral circulation modifies ischemia

Slowly developing coronary obstruction



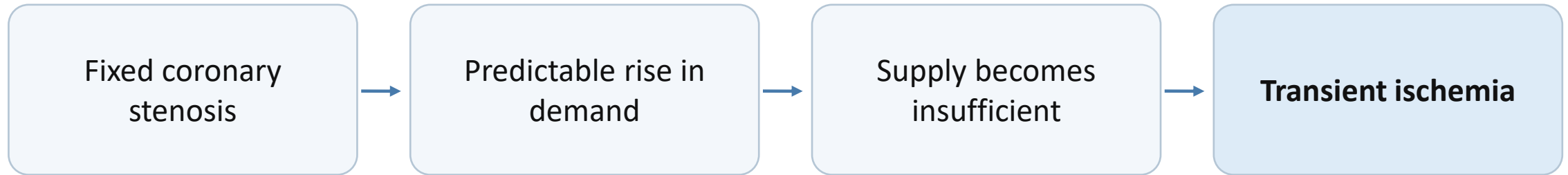
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graph TD; A[Slowly developing coronary obstruction] --> B[Collateral vessel formation]; A --> C[Alternative routes of perfusion]; D[Collateralization may mitigate the consequences of even severe fixed narrowing.]
```

Collateral vessel formation

Alternative routes of perfusion

Collateralization may mitigate the consequences of even severe fixed narrowing.

Stable angina: Core mechanism



Typical stable angina is the most common pattern.

Stable angina: Reproducible triggers

Physical activity

Increased workload

Psychological stress

Demand can rise without exercise

Emotional excitement

Higher myocardial requirements

Rest

Ordinarily does not provoke typical stable angina

Exertion unmasks limited perfusion reserve

CORONARY SUPPLY

Fixed stenosis

Limited extra flow

MYOCARDIAL DEMAND

Walking uphill

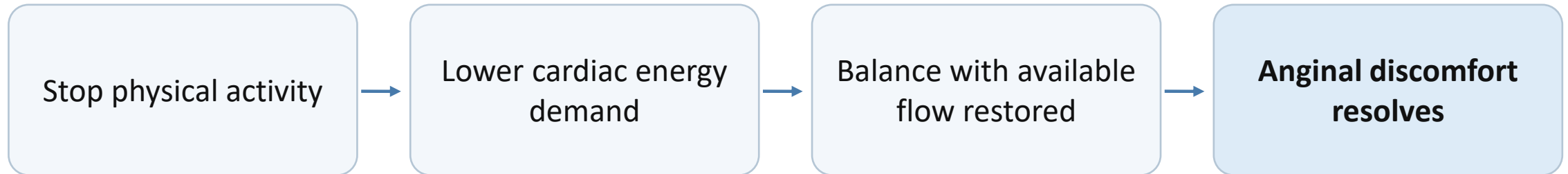
Climbing stairs

Physical effort

Mismatch → ischemia

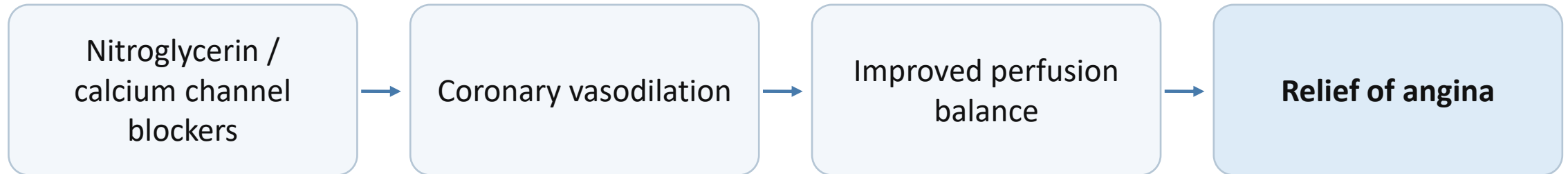
Conceptual mismatch during activity; Not a quantitative hemodynamic plot.

Rest relieves demand-driven ischemia



Improvement with rest is characteristic of the typical stable pattern.

Vasodilators and stable symptoms



The Robbins passage cites vasodilators as a mechanism of symptomatic relief.

This is a pathophysiologic explanation, not a prescribing recommendation.

Case: Reproducible exertional pain

A person develops squeezing substernal pressure each time they climb a steep staircase. The discomfort stops after resting.

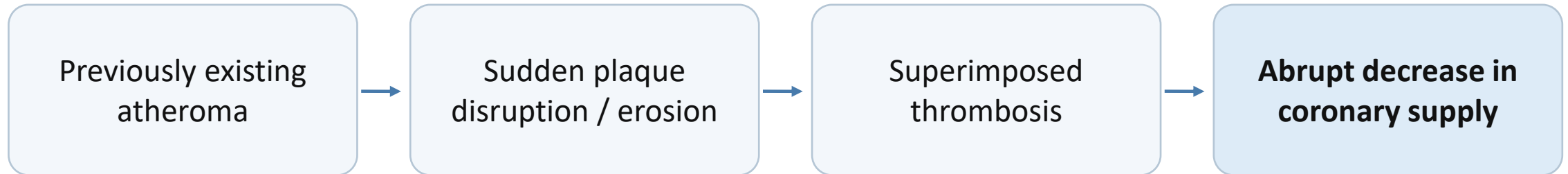
Question 1: Which angina pattern best matches the symptom trigger?

Question 2: Which coronary mechanism produces the demand threshold?

Case interpretation: Fixed coronary limitation

- Best fit: Stable (typical) angina.
- A chronic stenosing plaque constrains perfusion reserve.
- Exercise raises myocardial demand; Rest lowers demand below the symptom threshold.

Acute plaque change alters the clinical pattern



This is a pathway to unstable angina and other acute coronary syndromes.

Plaque rupture and plaque erosion

Plaque rupture

Fibrous cap disruption

Thrombogenic plaque contents exposed

Thrombosis may follow

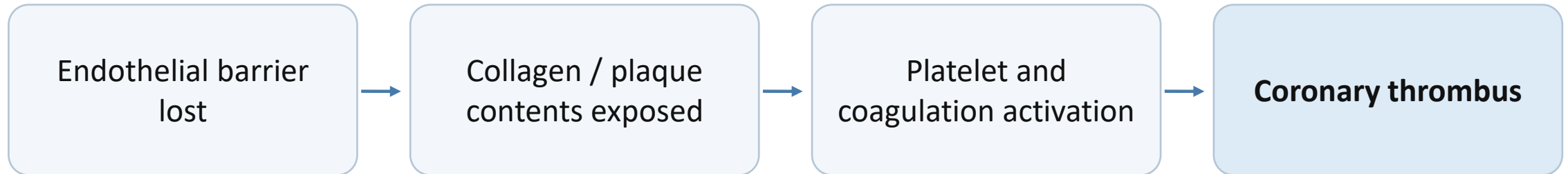
Plaque erosion

Loss / injury of luminal endothelium

Subendothelial structures exposed

Thrombosis may follow

Why plaque disruption is thrombogenic



Plaque disruption or erosion to acute thrombosis.

Thrombus size determines flow limitation

Thrombus on disrupted plaque

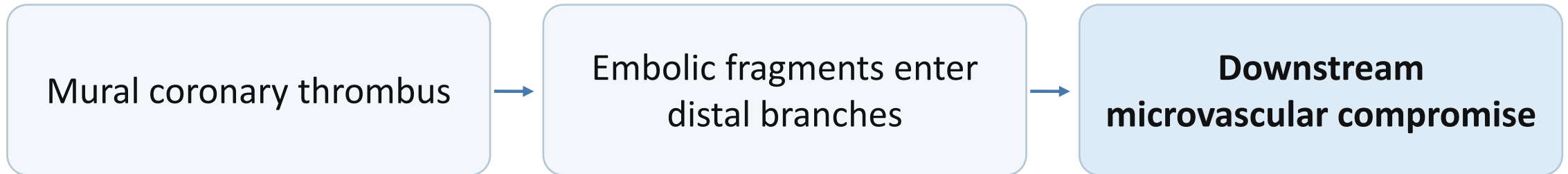
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graph TD; A[Thrombus on disrupted plaque] --> B[Partial obstruction → ischemia]; A --> C[Complete obstruction → often infarction];
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Partial obstruction → ischemia

Complete obstruction → often infarction

A nonocclusive thrombus can still cause substantial ischemia.

Distal thromboembolization



Distal thromboemboli and microinfarcts in the setting of unstable angina.

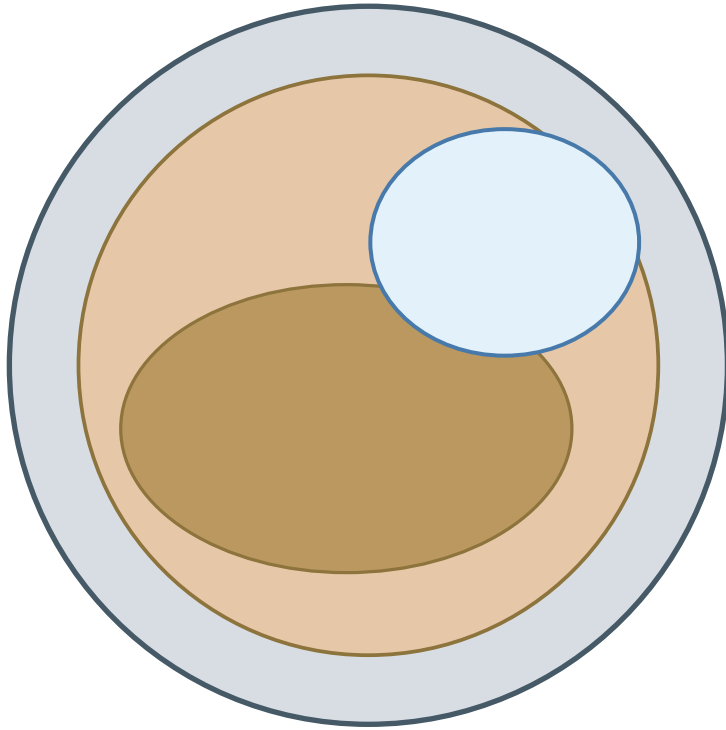
Focal microinfarction is not the defining lesion of angina itself.

A culprit plaque need not be critically stenotic

- Some plaques provoke few symptoms before disruption.
- Acute change—not only the pre-existing luminal narrowing—determines sudden coronary events.
- A stable symptom history cannot rule out a future acute plaque event.

Plaque stability and stenosis severity describe different properties.

Vulnerable plaque: Structural attributes



CORONARY ARTERY (CROSS-SECTION)

- Large lipid-rich atheromatous core.
- Thin overlying fibrous cap.
- Mechanical disruption exposes thrombogenic plaque material.

Cap strength depends on matrix balance

CORONARY SUPPLY

Smooth muscle cells

Collagen synthesis

MYOCARDIAL DEMAND

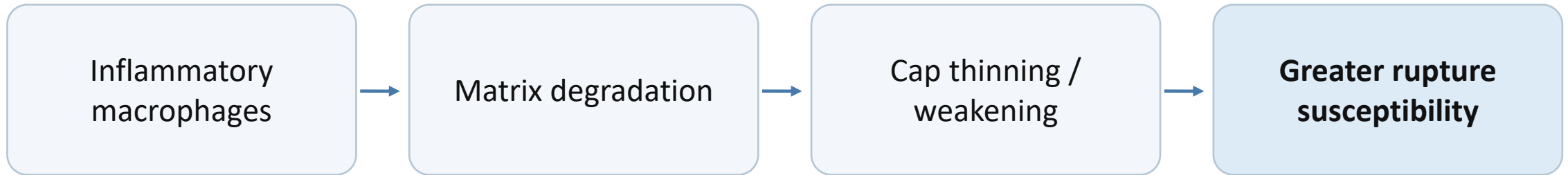
Macrophages

Matrix metalloproteinases

Mismatch → ischemia

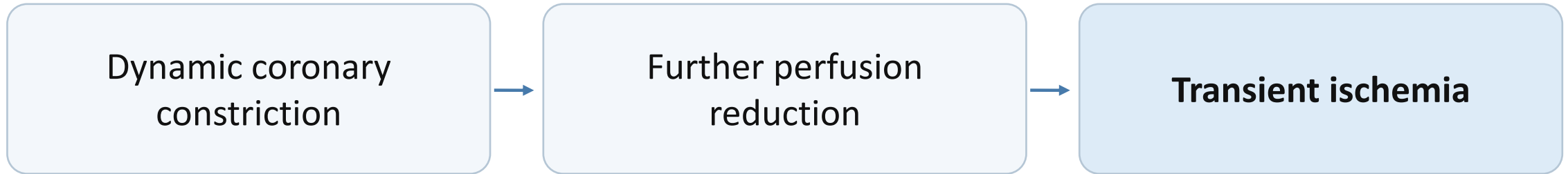
Plaque stability depends on synthesis versus breakdown of fibrous-cap matrix.

Inflammation promotes plaque vulnerability



The source identifies inflamed, smooth-muscle-poor plaques as especially vulnerable.

Vasospasm can accompany acute plaque change



Spasm may contribute alone or superimpose on plaque-related disease.

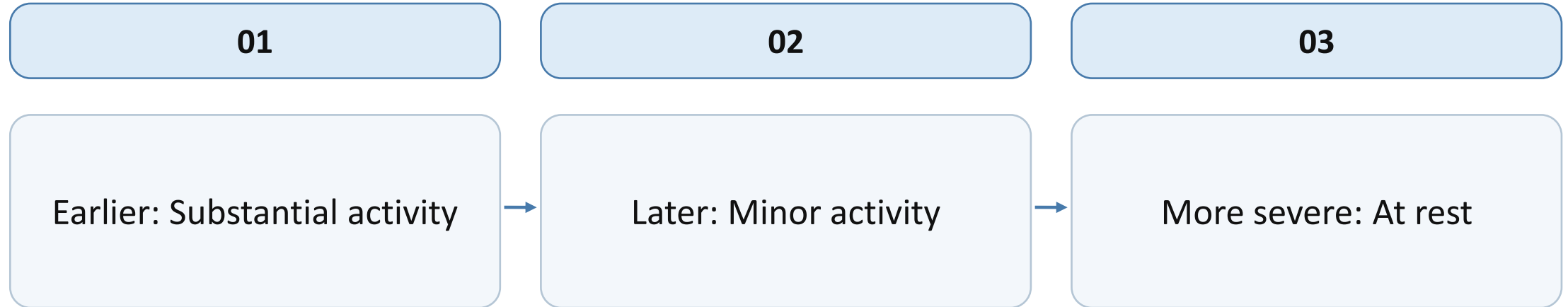
Plaque rupture, thrombosis and vasospasm are not mutually exclusive.

Unstable angina: Crescendo symptoms

Increasing frequency, duration, or severity of attacks

- Provoked by progressively less physical activity.
- May develop during rest.
- The Robbins text describes prolonged episodes, often >20 minutes.

Unstable angina: A falling exertional threshold



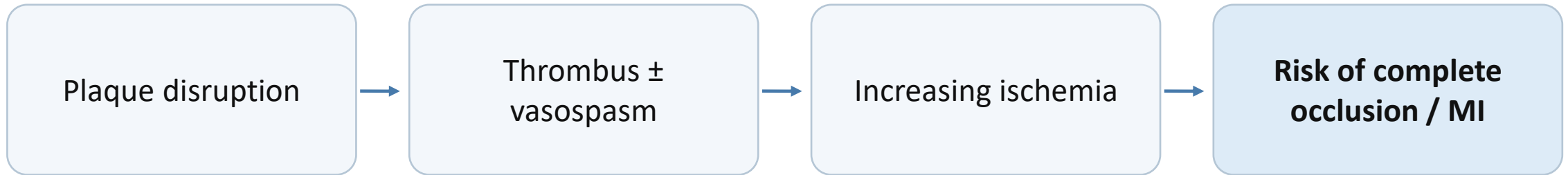
Qualitative clinical progression characteristic of a crescendo pattern.

Rest pain changes the clinical concern

- Unstable angina can occur without a rise in physical demand.
- A new perfusion limitation may result from plaque disruption, thrombus, or spasm.
- The pattern is a warning of possible progression to infarction.

A changing symptom threshold is more alarming than a reproducible stable threshold.

Unstable angina is an acute coronary warning



Robbins explicitly characterizes unstable angina as a harbinger of myocardial infarction.

Case: Angina becoming more frequent

Over several days, a patient's exertional substernal discomfort becomes more intense, occurs during shorter walks, and finally appears while seated.

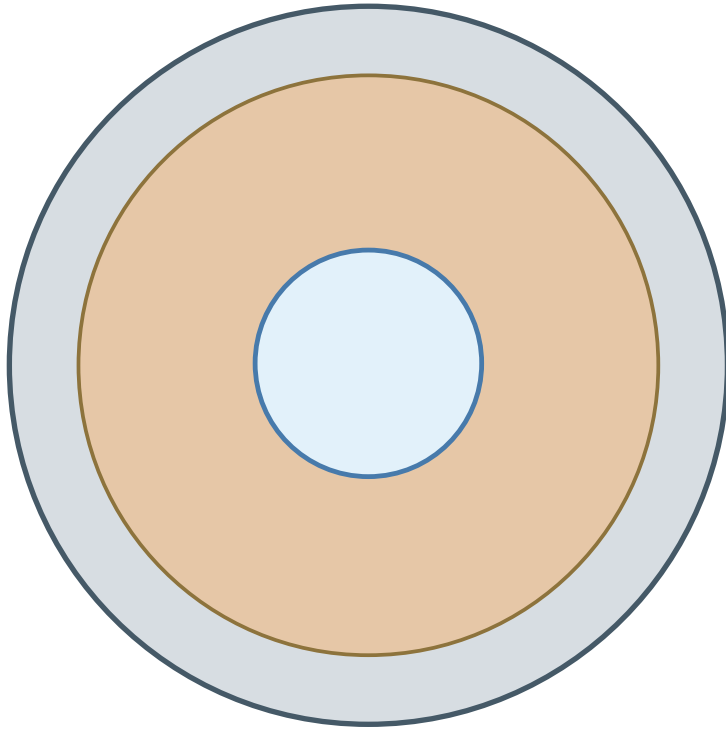
Question 1: Which new descriptor matters most?

Question 2: What underlying coronary change should be considered?

Case interpretation: Unstable angina

- The escalating, lower-threshold pattern is crescendo angina.
- Think of acute plaque alteration, mural thrombosis, and/or vasospasm.
- The risk of complete occlusion distinguishes this pattern from uncomplicated stable angina.

Variant angina: Dynamic coronary spasm



CORONARY ARTERY (CROSS-SECTION)

- Prinzmetal variant angina reflects transient coronary arterial spasm.
- The ischemia is episodic rather than predictably demand-triggered.
- Attacks can occur at rest.

Variant angina is not exertion-dependent

Stable angina	Prinzmetal variant angina
Predictable with increased demand	Unrelated to exertion
Chronic stenosing atherosclerosis	Episodic coronary spasm
Typically absent at rest	May appear at rest

Spasm and atherosclerosis can coexist

Variant angina episode

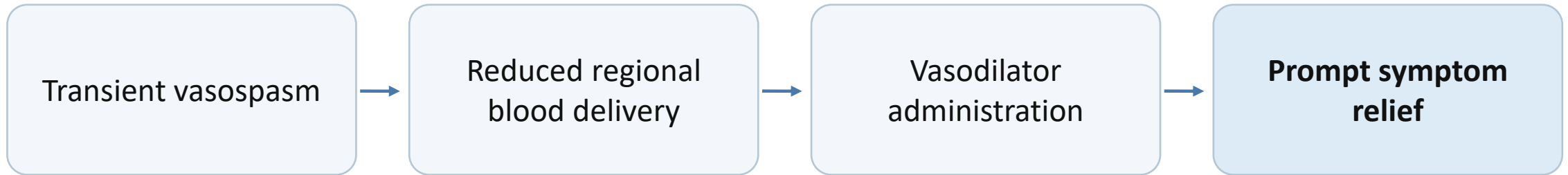
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graph TD; A[Variant angina episode] --> B[Coronary spasm]; A --> C[May coexist with atheromatous plaque];
```

Coronary spasm

May coexist with atheromatous plaque

The presence of fixed coronary disease does not exclude the variant mechanism.

Vasodilator response in variant angina



A generally prompt response to vasodilators.

Case: Episodic pain at rest

A person has abrupt episodes of chest discomfort while resting. The attacks do not track physical activity or changes in heart rate.

Question 1: What mechanism best explains the episodes?

Question 2: Would known atherosclerosis exclude that mechanism?

Case interpretation: Prinzmetal angina

- Pattern: Variant (Prinzmetal) angina.
- Transient coronary spasm explains ischemia independent of exertion.
- Coexisting atherosclerosis does not rule out vasospastic episodes.

Three syndromes: Mechanistic comparison

Feature	Stable	Variant	Unstable
Dominant mechanism	Fixed stenosis	Coronary spasm	Acute plaque change ± thrombus
Typical trigger	Exertion / stress	Not activity-linked	Lower effort / rest
Pattern over time	Reproducible	Episodic	Crescendo
Rest attacks	Not typical	Can occur	Can occur
Clinical implication	Demand limit	Dynamic constriction	Threat of infarction

Anginal syndromes can overlap

Stenosis

Chronic plaque reduces
reserve

Spasm

Dynamic constriction lowers
flow

Thrombosis

Acute plaque change
abruptly lowers flow

The same patient may have more than one coronary mechanism.

Anatomic plaque $\neq$ symptoms $\neq$ tissue death

What is observed?	What it establishes
Coronary atheroma	A structural coronary lesion
Chest discomfort	A potential ischemic symptom
Transient ischemia without necrosis	Angina pectoris
Myocyte necrosis	Myocardial infarction, not angina alone

Angina has no defining myocyte necrosis

- Myocardial ischemia can be severe enough to activate pain pathways.
- The defining anginal episode does not progress to myocyte death.
- The underlying coronary vessel may nevertheless contain severe atherosclerotic pathology.

Do not equate a vascular plaque with myocardial infarction.

Morphology: Identify the relevant tissue

Arterial wall

Atherosclerosis / cap
structure

Arterial lumen

Fixed narrowing, thrombus
or spasm

Myocardium

Transient ischemia; No
defining necrosis

Interpret the coronary lesion and its myocardial consequence separately.

How to reason from an anginal history

1

Is there predictable demand-triggered discomfort?

2

Are episodes independent of exertion?

3

Is the frequency, duration, or severity worsening?

4

Could ischemia be silent or present atypically?

A mechanistic interpretation framework, not a validated diagnostic algorithm.

Pitfall: Pain characteristics alone are insufficient

- Symptoms are the perceived output of an ischemic process.
- Some episodes are silent or manifest through dyspnea or autonomic symptoms.
- Overlapping mechanisms prevent a simple one-symptom/one-lesion correspondence.

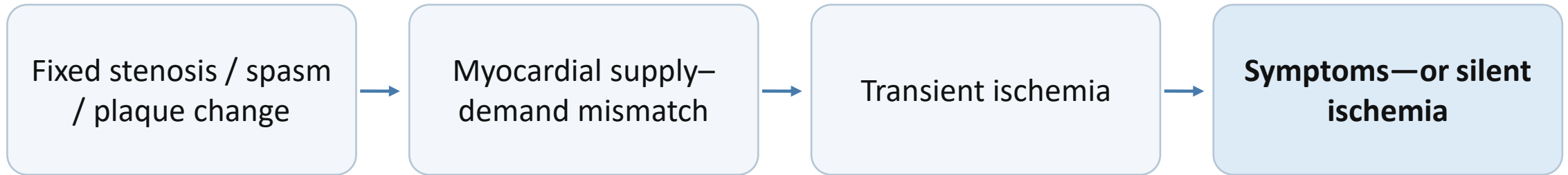
Clinical patterns raise mechanistic hypotheses; They do not anatomically prove the culprit lesion.

Pitfall: Fixed stenosis does not predict plaque rupture

- Chronic stenosis determines perfusion reserve.
- Cap composition and inflammation influence plaque rupture susceptibility.
- Some culprit plaques were not critically narrowing the lumen before disruption.

Ischemia risk and acute thrombosis risk require distinct pathological reasoning.

Integrated pathologic model



Unstable plaque change adds a clinically important risk of coronary occlusion.

Four conclusions to retain

- Angina is transient myocardial ischemia without myocyte necrosis.
- Stable angina tracks limited flow reserve under increased demand.
- Prinzmetal angina reflects episodic coronary spasm; Unstable angina reflects acute plaque-related flow compromise.
- Silent ischemia and overlapping mechanisms limit symptom-only interpretation.

Reference and scope

Robbins, Cotran & Kumar. Pathologic Basis of Disease. 11th ed. (2026).

Chapter 12, The Heart — Ischemic Heart Disease; Chronic Arterial Occlusion; Acute Plaque Change; Angina Pectoris.

Source pages: 492–494.

All vascular drawings are original editable schematics; not scale drawings, photographs, or patient-specific images.