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Summary of Hemodynamic Changes in Mitral Regurgitation (MR)

Hemodynamic Changes in Different Stages of Mitral Regurgitation

Parameter	Acute MR	Compensated Chronic MR	Decompensated Chronic MR
Preload (Left Ventricular End-Diastolic Volume)	↑↑ (High)	↑ (Mild Increase)	↑ (Mild Increase)
Afterload (Resistance Against Ejection)	↓ (Low)	No Change	↑ (High)
Ejection Fraction (EF)	↑ (Hyperdynamic LV function)	↑ (Initially Maintained)	↓ (LV dysfunction develops)
Forward Stroke Volume (Amount of Blood Pumped to Aorta)	↓ (Low, due to regurgitant flow into LA)	Normal (Compensated State)	↓↓ (Severe Reduction, Heart Failure Develops)

Acute Mitral Regurgitation

- **Cause**: Often due to **chordae tendineae rupture**.
- **Pathophysiology**:
    - The **LA has normal size & compliance**, so regurgitant blood from the **LV causes a sudden increase in LA pressure**.
    - This leads to **acute pulmonary edema**, causing **dyspnea & respiratory distress**.
    - **LV ejection fraction (EF) remains high**, but **forward stroke volume is reduced**, leading to **hypotension & cardiogenic shock**.
    - **LV afterload decreases** as blood escapes into the LA during systole.

Chronic Compensated Mitral Regurgitation

- **Cause**: Progressive **valvular degeneration**, mitral annular dilation, or rheumatic disease.
- **Pathophysiology**:
    - **LA enlarges (LA dilation)** to accommodate regurgitant volume, preventing a sudden rise in **LA pressure**.

- **Ejection fraction (EF) remains normal or high** due to compensatory LV changes.
- **Stroke volume is maintained**, & pts are often **asymptomatic**.
- **Afterload remains unchanged**, & **pulmonary congestion is minimal**.

Chronic Decompensated Mitral Regurgitation

- **Cause**: **LV dilation & progressive myocardial dysfunction**.
- **Pathophysiology**:
  - **LV dilates**, reducing its contractility.
  - **Ejection fraction (EF) falls**, leading to **heart failure symptoms**.
  - **Forward stroke volume decreases**, causing **fatigue, hypotension, & poor perfusion**.
  - **Left atrial & pulmonary pressures increase**, leading to **pulmonary congestion & dyspnea**.

Educational Objective

- **Acute mitral regurgitation leads to increased LA pressure, pulmonary edema, & decreased forward cardiac output, causing hypotension**.
- **Chronic compensated mitral regurgitation allows the LA & LV to adapt, maintaining cardiac output while minimizing symptoms**.
- **Chronic decompensated mitral regurgitation results in LV dysfunction, reduced EF, & symptomatic heart failure**.

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Summary Table:

Topic	**Details**
Condition	MI leads to a **new systolic murmur** that resolved after revascularization. This murmur was caused by **mitral regurgitation (MR)** due to **papillary muscle dysfunction.**
Cause of Murmur	MI caused **ischemia of the papillary muscle** & **adjacent left ventricular wall**, leading to **hypokinesis & outward displacement** of the papillary muscle. This prevents **complete mitral valve closure**, leading to **MR.**

Topic	Details
Pathophysiology	- Hypokinesis of papillary muscle disrupts **tension on chordae tendineae** & prevents **mitral valve closure.** - Timely **coronary revascularization** restores **blood supply**, improving **papillary muscle function** & resolving **MR.**
Papillary vs. Papillary Rupture	- **Papillary muscle dysfunction** is **reversible** with **revascularization.** - **Papillary muscle rupture** is a **mechanical complication** of MI that occurs **within 3-5 days** & **requires surgical repair.**
Incorrect Answers	- **Aortic root & aortic valve leaflet function** are **not affected** by myocardial ischemia & would **not** explain a **systolic murmur** during acute MI. - **Interventricular septal rupture** occurs **3-5 days after MI** & presents with **sudden hypotension, dyspnea, pulmonary edema, & a harsh holosystolic murmur at the left sternal border.** It **does not resolve** with revascularization & **requires surgery.** - **Mitral valve chordae tendineae** are **not affected by myocardial ischemia** but rupture in **myxomatous mitral valve disease** (mitral valve prolapse), **rheumatic fever**, or **endocarditis.**

Additional Details:

- **Papillary muscle ischemia in MI** is the **most common cause of acute mitral regurgitation.**
- **Timely restoration of blood supply via revascularization** improves **papillary muscle dysfunction**, allowing **MR to resolve.**
- **Mechanical complications (rupture) require surgical intervention**, as opposed to **ischemic dysfunction, which can be reversed with treatment.**

Educational Objective:

- **MI** causing **ischemia of the papillary muscle** can result in **acute mitral regurgitation** & a **new systolic murmur.**
- **Coronary revascularization** can restore **blood supply** & **resolve mitral regurgitation** caused by **ischemic dysfunction.**
- **Papillary muscle rupture, in contrast, is a mechanical complication that does not resolve & requires surgery.**

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Summary Table:

Topic	Details
Condition	**Mitral regurgitation (MR)** with a **blowing holosystolic murmur** best heard at the **cardiac apex** with **radiation to the axilla.** The MR is likely due to **rheumatic heart disease (RHD).**
Geographic and Clinical Clues	RHD is **most commonly seen in** patients from **Latin America, Africa, and Asia.** The patient's **emigration history & childhood knee swelling** suggest a past episode of **acute rheumatic fever,** which predisposes to **rheumatic valve disease.**
Mitral Valve Involvement in RHD	- **Mitral regurgitation is more common in young pts (<25 years old).** - **Mitral stenosis is more common in middle-aged pts (>30 years old).** - **Mixed mitral valve disease** (both regurgitation & stenosis) becomes **more frequent with age.**
Incorrect Answer Explanations	- **Aortic root dilation and regurgitation** present with an **early diastolic murmur at the right upper sternal border**, not a holosystolic murmur at the apex - **Atrial septal defect (ASD) murmur** is a **faint midsystolic murmur at the left upper sternal border** with **fixed splitting of S2**, unrelated to mitral regurgitation - **Bicuspid aortic valve** is associated with **aortic stenosis**, which presents with a **crescendo-decrescendo systolic murmur at the right upper sternal border**, not MR - **Mitral stenosis from RHD** has a **diastolic, rumbling murmur with an opening snap**, different from mitral regurgitation.

Additional Details:

- **Mitral regurgitation murmur is holosystolic** because it occurs **throughout systole.**
- **Radiation to the axilla** helps distinguish **mitral regurgitation from other murmurs.**
- **Rheumatic heart disease is the leading cause of mitral valve pathology worldwide,** particularly in areas with **limited access to early antibiotic treatment for streptococcal infections.**

Educational Objective:

- **Mitral regurgitation causes a holosystolic murmur best heard at the cardiac apex with radiation to the axilla.**
- **Rheumatic heart disease is a common cause of both mitral regurgitation & mitral stenosis.**
- **It is most commonly seen in pts from Latin America, Africa, or Asia.**

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Summary of Mitral Regurgitation (MR) & Hemodynamic Effects

Key Clinical Findings

- **Symptoms**
    - Dyspnea, orthopnea, & lung crackles suggest decompensated left-sided heart failure.
    - A **holosystolic murmur** radiating to the axilla is classic for **mitral regurgitation (MR)**.
- **Blood Flow Dynamics in MR**
    - Blood is ejected **forward** through the **aortic valve** (forward stroke volume).
    - Some blood is forced **backward** through the **incompetent mitral valve** (regurgitant stroke volume).
    - The **distribution of blood flow** between these two pathways depends on **left ventricular afterload**.

Determinants of Left Ventricular Afterload

- **Resistance to forward flow**
    - **Mainly determined by aortic pressure (systolic BP).**
- **Resistance to regurgitant flow**
    - **Determined by the mitral valve orifice size** during systole.
    - **Influenced by left atrial compliance** (in chronic MR, the LA becomes more compliant, leading to lower pressures that facilitate greater regurgitant flow).

Effects of Systemic Vascular Resistance (SVR)

- **Aortic pressure can vary significantly with changes in systemic vascular resistance (SVR).**
- **A reduction in SVR leads to**
    - **Decreased systemic BP**
    - **Increased ratio of forward to regurgitant blood flow**
    - **Pharmacologic vasodilators** (e.g., **nitroprusside**) increase forward cardiac output & reduce pulmonary congestion in pts with MR.

Analysis of Answer Choices

Choice	Explanation
Choices A and E	**A decrease in heart rate → Increased venous return (preload) → More stroke volume**. However, both **forward & regurgitant flow increase equally**, so the **ratio of forward to regurgitant flow remains unchanged**.
Choice C	**Reduction in venous return** leads to **lower stroke volume**, decreasing both forward & regurgitant flow. However, **the ratio of forward to regurgitant flow remains the same**.
Choice D	**Increased left ventricular contractility** raises stroke volume, increasing both **forward & regurgitant flow equally**. Since both increase proportionally, **the ratio of forward to regurgitant flow remains unchanged**.

Educational Objective

- **Left ventricular afterload** in mitral regurgitation is determined by the **balance of resistance between forward flow (aortic pressure) & regurgitant flow (left atrial pressure).**
- **Lowering systemic vascular resistance (SVR) increases the ratio of forward to regurgitant blood flow**, improving cardiac output & reducing pulmonary congestion.

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Summary of Mitral Regurgitation (MR) & S3 Gallop

Key Clinical Features

- **Mitral Regurgitation (MR)**
  - Identified by a **holosystolic murmur** at the apex, radiating to the axilla.
  - Caused by **regurgitant blood flow** from the **LV to the LA** during systole.
  - Leads to **increased LA pressure & volume overload**, causing excessive **blood reentering the LV during diastole**.
  - **Severe MR is associated with an audible S3 gallop**, indicating **left-sided volume overload**.
  - **Absence of an S3 gallop can be used to exclude severe chronic MR.**
- **S3 Gallop**
  - Caused by the **sudden cessation of blood flow** into the LV during **passive diastolic filling**.
  - More prominent with **large volumes of blood flow** or a **dilated left ventricle**.

- While it can be normal in **young adults**, an **S3 in older adults** is usually a **sign of heart failure**.
- **Best indicator of severe MR** with left-sided **volume overload**.

Analysis of Answer Choices

Choice	Explanation
Choice B	**S4 is a low-frequency diastolic sound** caused by the **atrial kick against a stiff LV wall**. It is associated with **hypertrophic cardiomyopathy** or **concentric LV hypertrophy** from conditions like **HTN or aortic stenosis**.
Choice C	**Mid-systolic click** is characteristic of **mitral valve prolapse (MVP)**. It results from **sudden tensing of the chordae tendineae** as the **valve leaflets billow into the left atrium**. The **timing of the click** varies with LV volume & occurs earlier with maneuvers that **decrease LV volume**.
Choice D	**Opening snap** is an **early diastolic sound** heard after S2 in **mitral or tricuspid stenosis**. A **shorter S2-to-opening snap interval** is associated with **more severe mitral stenosis**.
Choice E	**Pulmonic valve stenosis** causes **delayed pulmonic valve closure**, leading to **widened splitting of S2**. The **splitting increases with inspiration** due to greater venous return to the right heart.

Educational Objective

- **Severe mitral regurgitation causes left-sided volume overload**, leading to an **S3 gallop** due to **regurgitant blood reentering the ventricle during mid-diastole**.
- **Absence of an S3 gallop suggests that severe chronic MR is unlikely**.

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Summary of Mitral Regurgitation (MR) & Left Atrial Pressure Tracings

Key Clinical Features

- **Mitral Regurgitation (MR)**
  - **Backflow of blood from the LV to the LA** during systole due to an **incompetent mitral valve**.

- **Elevated LA pressure** occurs due to increased **volume overload** in the LA.
- **Characteristic "early & large V wave" seen on LA pressure tracings**, reflecting the regurgitant volume.
- **Atrial dilation** can develop over time, increasing the risk for **atrial fibrillation**.
- **Symptoms of decompensated heart failure** include **dyspnea, orthopnea, & palpitations**.

Analysis of Answer Choices

Choice	Explanation
Choice A	**Aortic regurgitation** involves backflow from the **aorta into the LV** during diastole. Leads to **loss of aortic pressure** & **elevated LV end-diastolic volume** due to compensatory stroke volume increase. Characterized by **loss of the aortic dicrotic notch** & **rapid aortic pressure decline during diastole**.
Choice B	**Aortic stenosis** obstructs **LV outflow**, causing **discordance between LV & aortic systolic pressures**. Pressure tracings reveal **peak LV systolic pressure significantly exceeding aortic systolic pressure**.
Choice D	**Mitral stenosis** leads to **elevated LA pressures throughout the cardiac cycle**. Peak atrial pressure occurs at the **atrial kick** just before mitral valve closure **at the end of ventricular diastole**.
Choice E	**Tricuspid regurgitation** produces an **early & large V wave on RA pressure tracings**, similar to the pattern seen in MR. However, **left-sided pressure tracings (LA, LV, aorta) are minimally affected**.

Educational Objective

- **Mitral valve regurgitation causes an elevated LA pressure, particularly during ventricular systole**.
- **This creates a characteristic "early & large V wave" seen in LA pressure tracings**.
- **Over time, atrial dilation & secondary complications such as atrial fibrillation & decompensated heart failure can occur**.