Department of Cardiology and Vascular Medicine Hasanuddin University
Cardiology and Vascular Medicine Study Program
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2024

CASE REPORT

Beyond the Operating Room:

The Challenge of Low Cardiac Output Syndrome After Mitral and Aortic Valve Replacement

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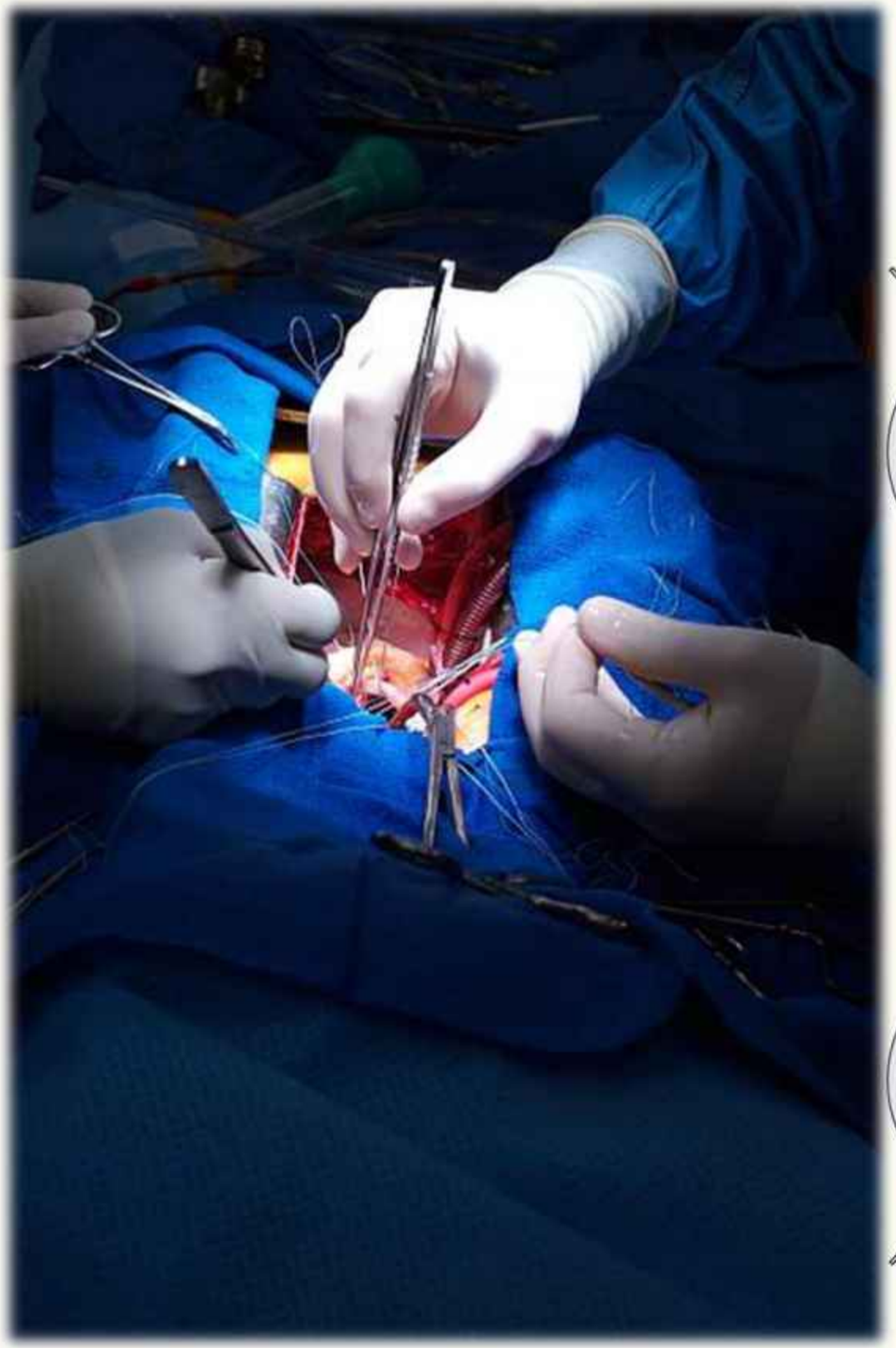


Introduction

Low Cardiac Output Syndrome (LCOS) is a critical complication following cardiac valve replacement surgeries.

This presentation explores the challenges of LCOS, focusing on its occurrence after mitral and aortic valve replacements.

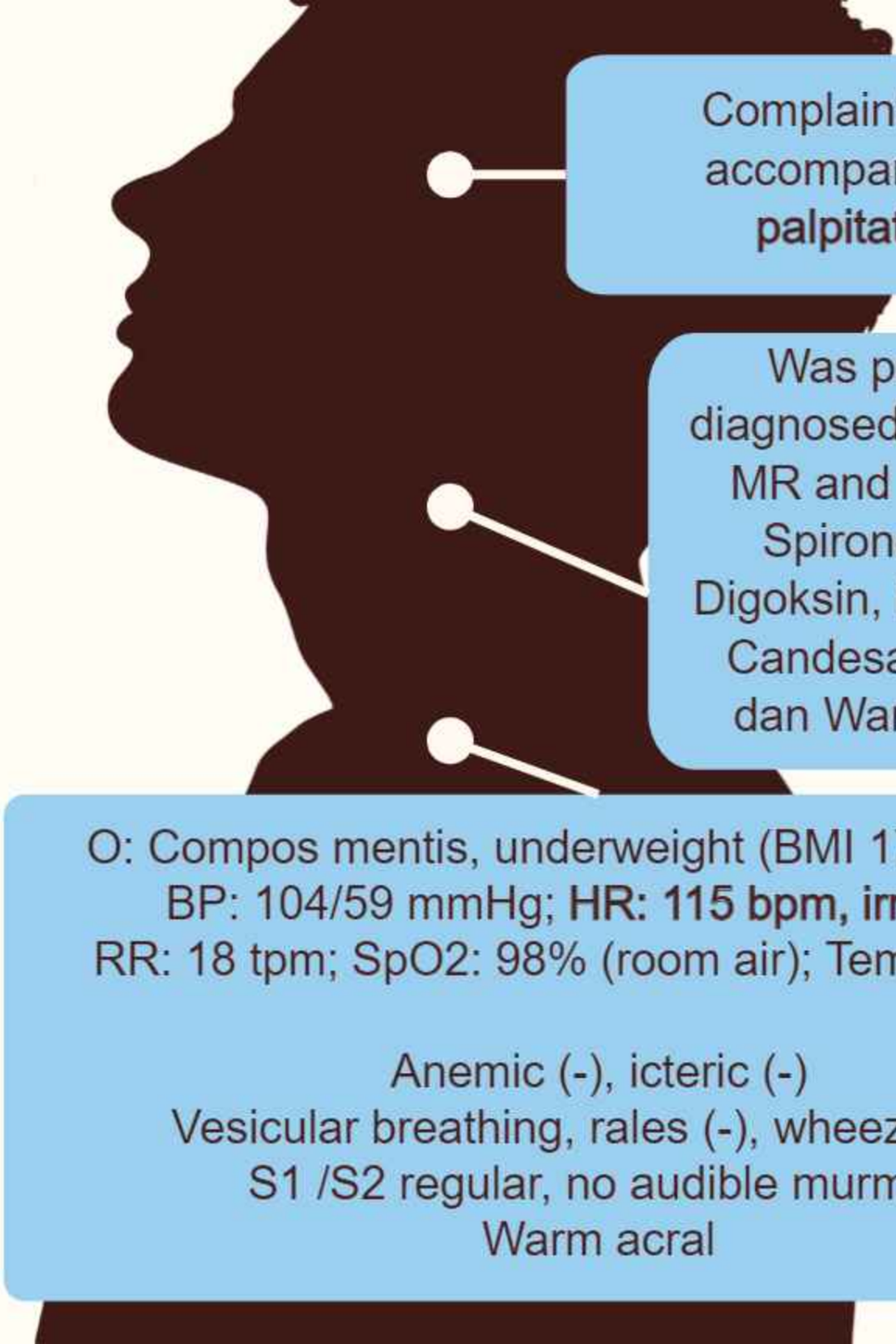
We'll review the definition, risk factors, pathophysiology, diagnostic parameters, and management strategies for this complex post-operative condition.

Easterwood, R.M., Bostock, I.C., Nammalwar, S., McCullough, J.N., Iribarne, A., 2018. The evolution of minimally invasive cardiac surgery: from minimal access to transcatheter approaches. Future Cardiol 14, 75–87.
Malaisrie, S.C., Barnhart, G.R., Farivar, R.S., Mehall, J., Hummel, B., Rodriguez, E., Anderson, M., Lewis, C., Hargrove, C., Allawadi, G., 2014. Current era minimally invasive aortic valve replacement: techniques and practice. J Thorac Cardiovasc Surg 147, 6–14.
Modi, P., Hassan, A., Chitwood Jr, W.R., 2008. Minimally invasive mitral valve surgery: a systematic review and meta-analysis. European Journal of Cardio-Thoracic Surgery 34, 943–952.

Case Illustration

A 30-year-old female presented with a **history of intermittent shortness of breath for the last 1 week**.

History of **prior SoB (+),** DOE (+), PND (+), Orthopneu (+)



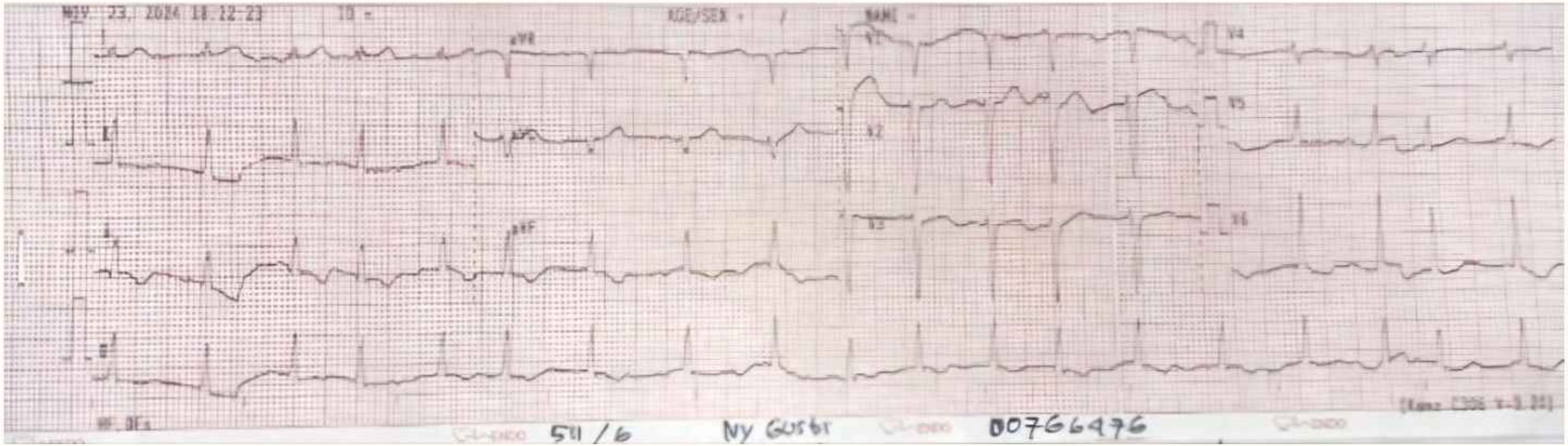
Complaints were accompanied by **palpitations**

Was previously diagnosed with Severe MR and consumes Spironolaktone, Digoksin, Furosemide, Candesartan 4 mg, dan Warfarin 2 mg

O: Compos mentis, underweight (BMI 17.3 kg/m2)
BP: 104/59 mmHg; **HR: 115 bpm, irregular**
RR: 18 tpm; SpO2: 98% (room air); Temp: 36.5°C

Anemic (-), icteric (-)
Vesicular breathing, rales (-), wheezing (-)
S1 /S2 regular, no audible murmur
Warm acral

ECG Findings



Supraventricular rhythm, HR avg 110 bpm, irregularly irregular, normoaxsis, fibrillatory P wave, QRS duration 0.06 sec, T inverted II, III, aVF, LVH

Conclusion: Atrial Fibrillation Rapid Ventricular Response with Ischemic Inferior Wall

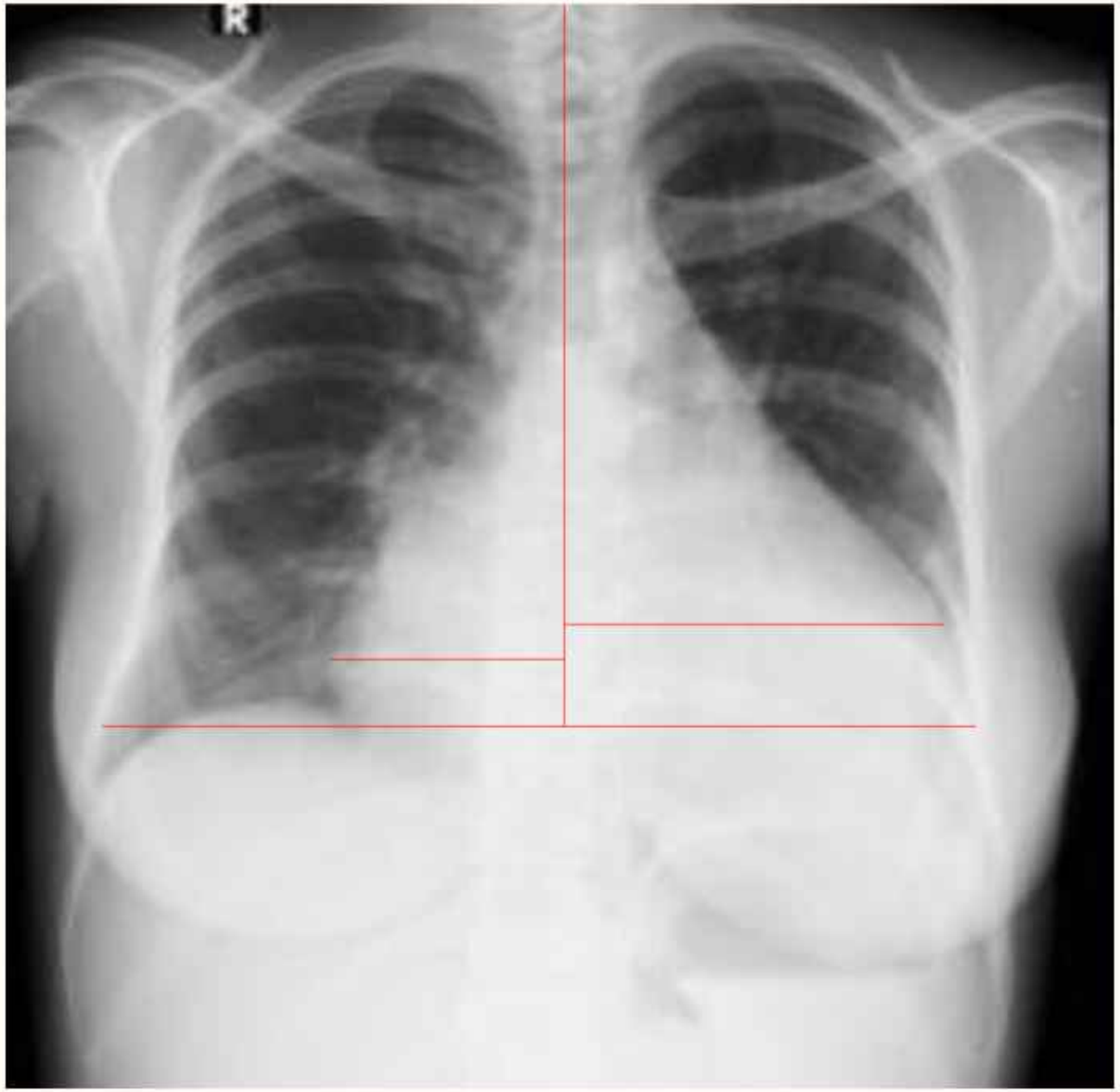
LAB FINDINGS

Complete Blood Count	Result	Reference Value
WBC	7500	4,000-10,000/ul
HGB	11.7	12-16 gr/dl
PLT	324,000	150,000-400,000/ul
NEU	70.2	52-75%
LYMPH	18.1	20-40%
Coagulation		
PT	14.1	10-14 sec
APTT	28.6	22-30 sec
INR	1.34	-

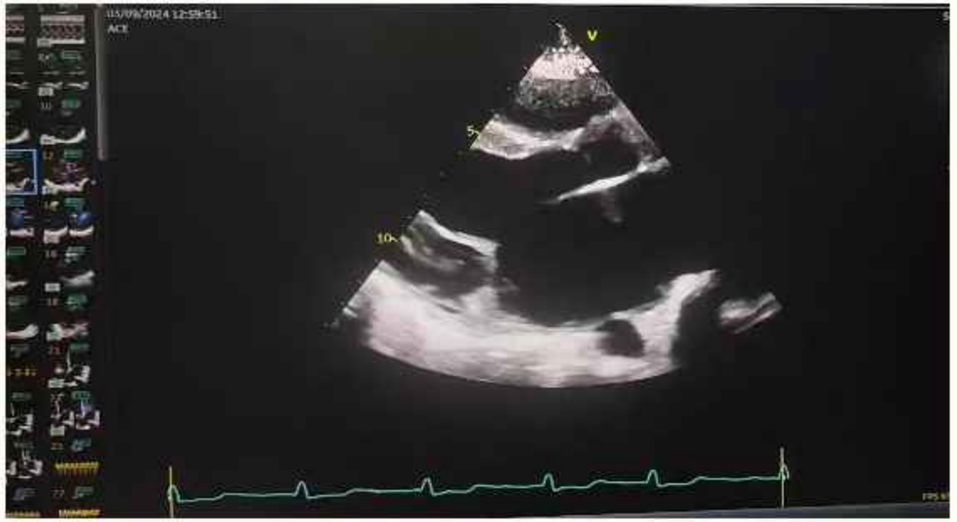
Blood Chemistry	Result	Reference Value
RBG	118	140 mg/dl
Ureum	39	10-50 mg/dl
Kreatinin	0.99	<1.3 mg/dl
SGOT	40	<38 U/L
SGPT	13	<41 U/L
Natrium	134	136-145 mmol/l
Kalium	4.5	3.5-5.1 mmol/l
Chloride	103	97-111 mmol/l

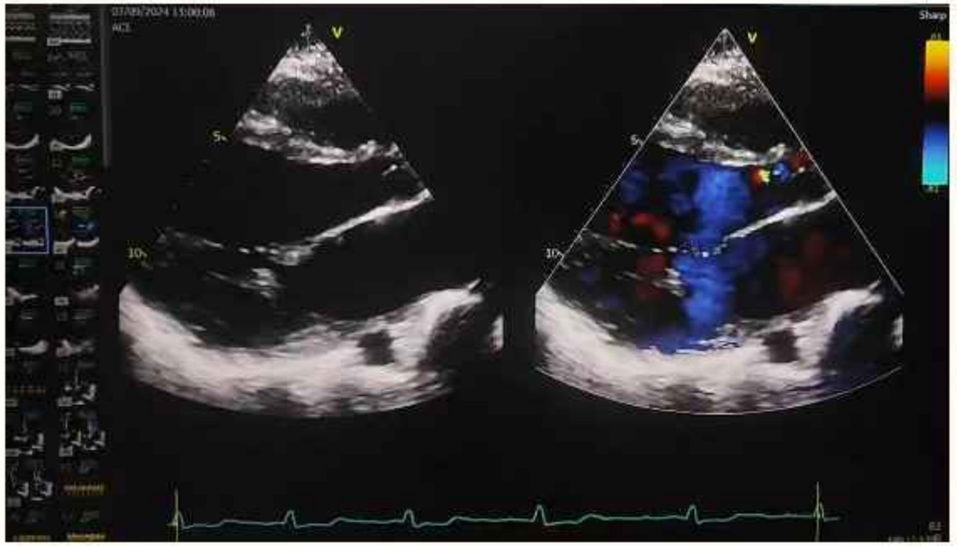
Chest X-Ray

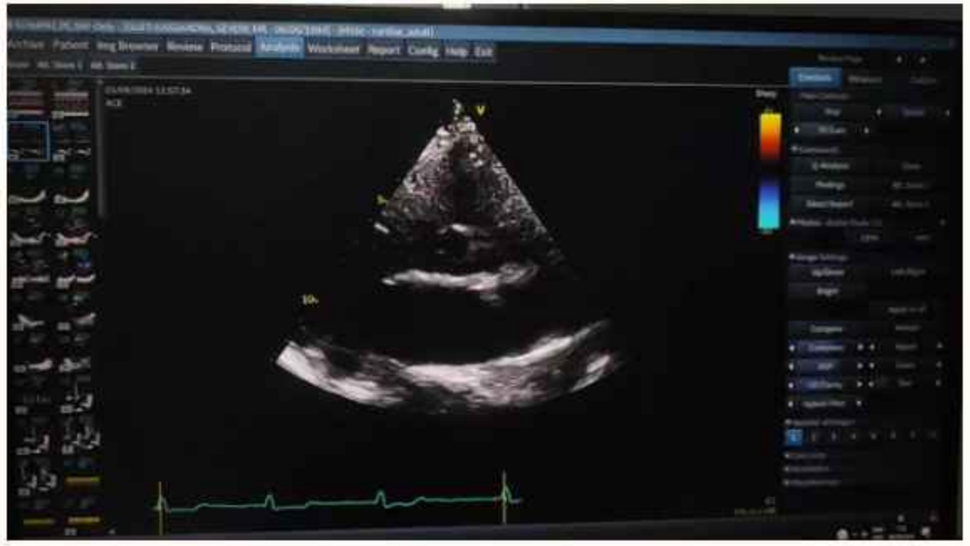
- Cardiomegaly with left ventricular hypertrophy

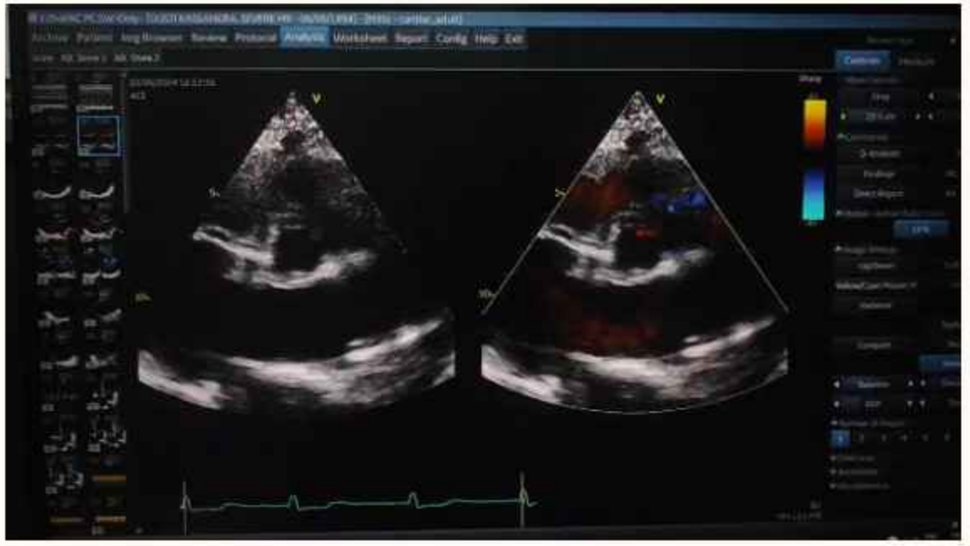


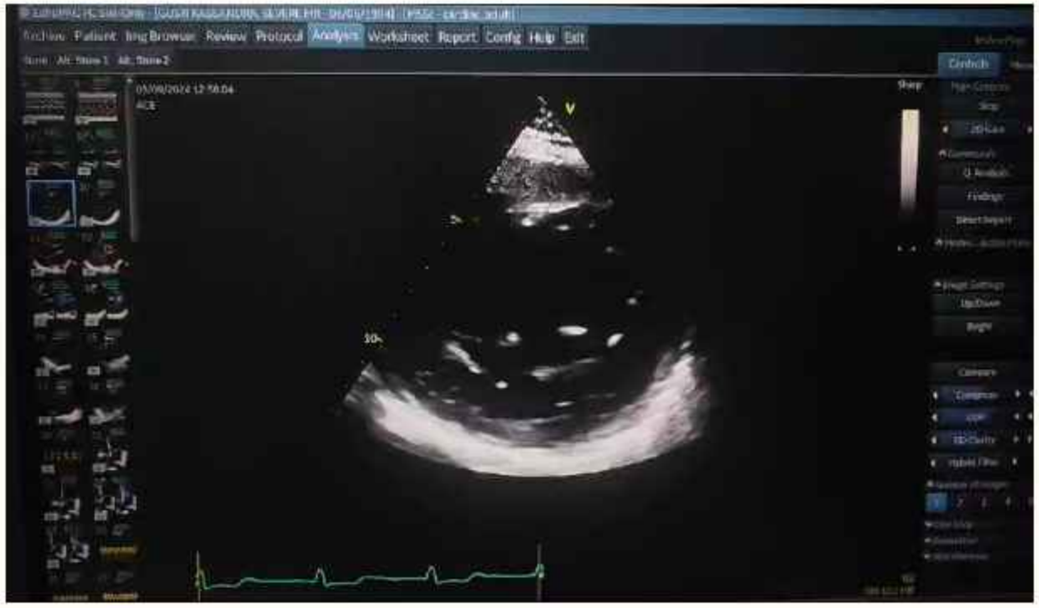
TRANSTHORACAL ECHOCARDIOGRAPHY PRE-OP







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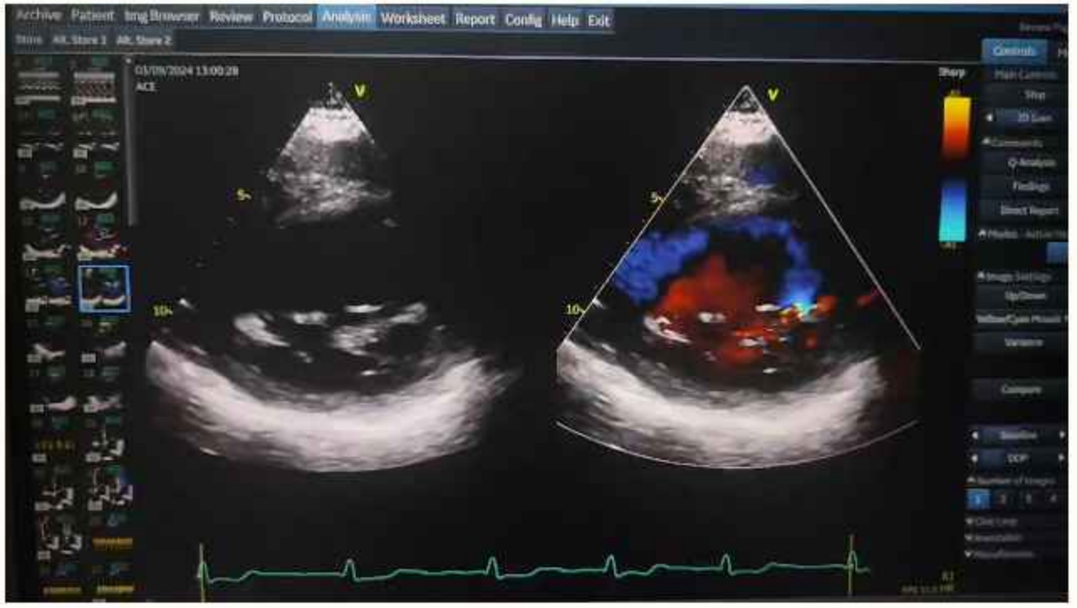
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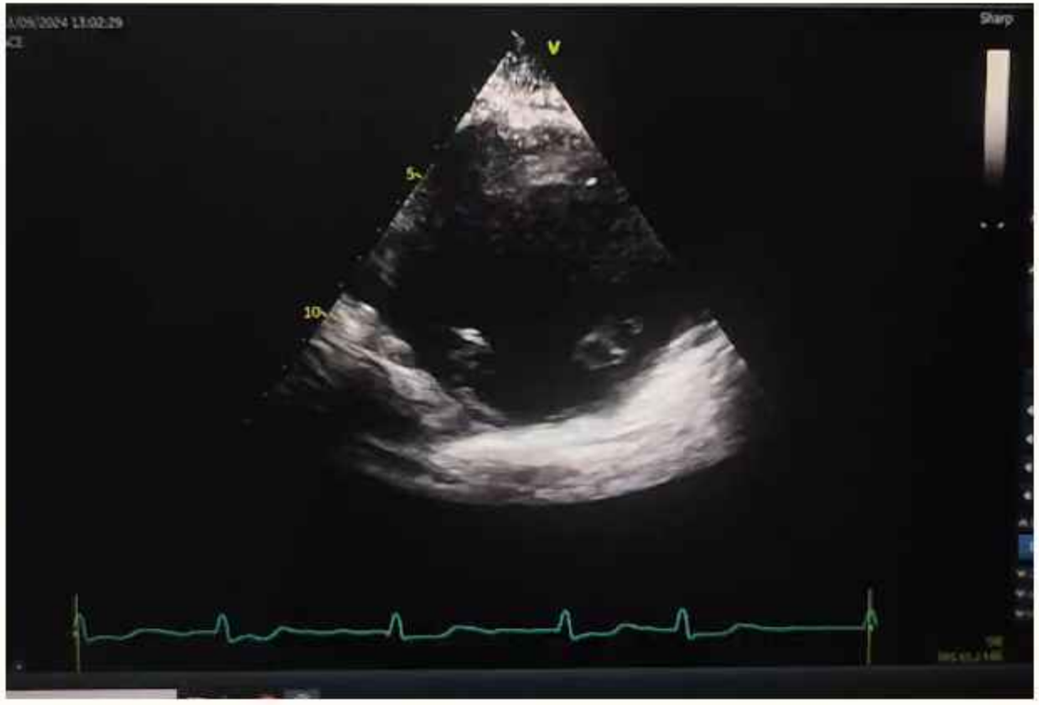
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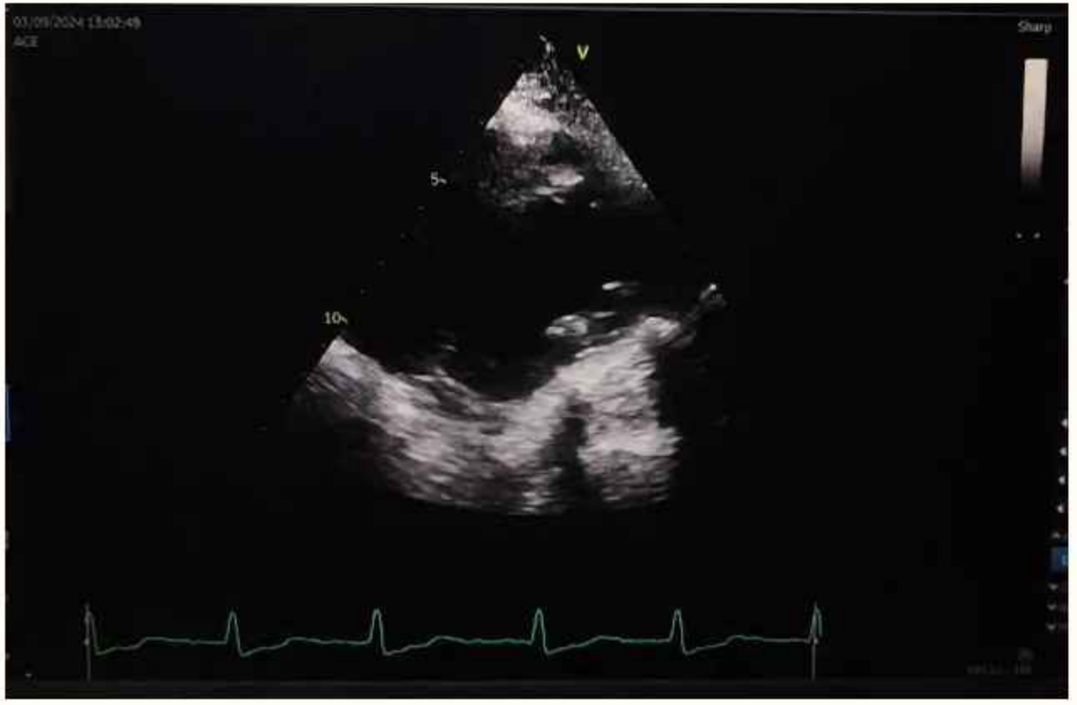
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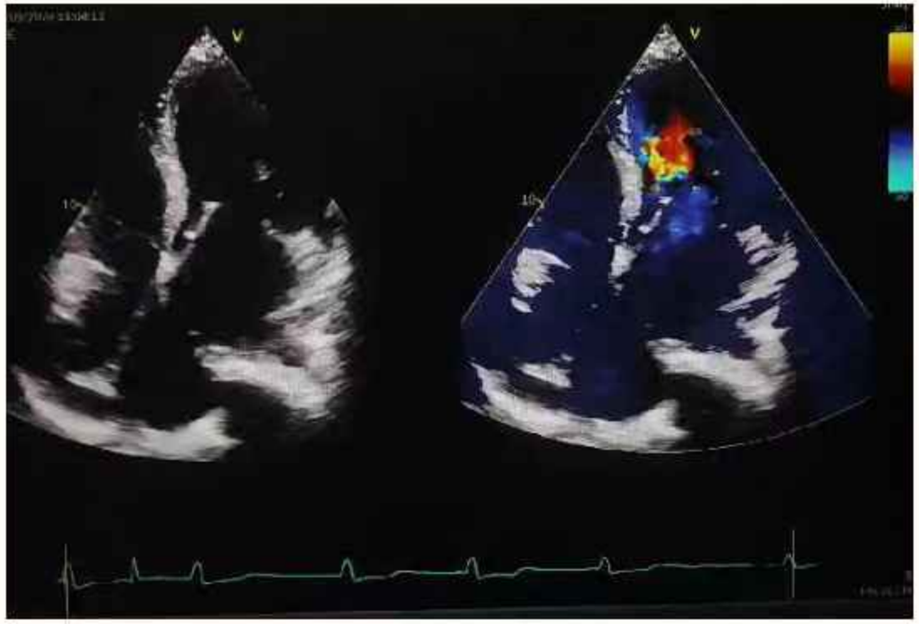
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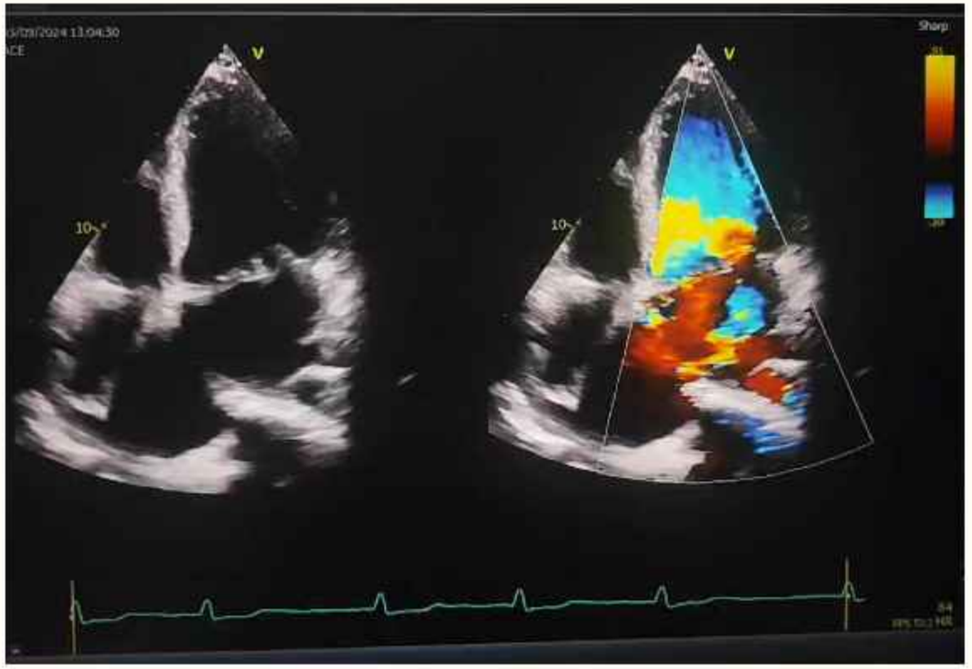
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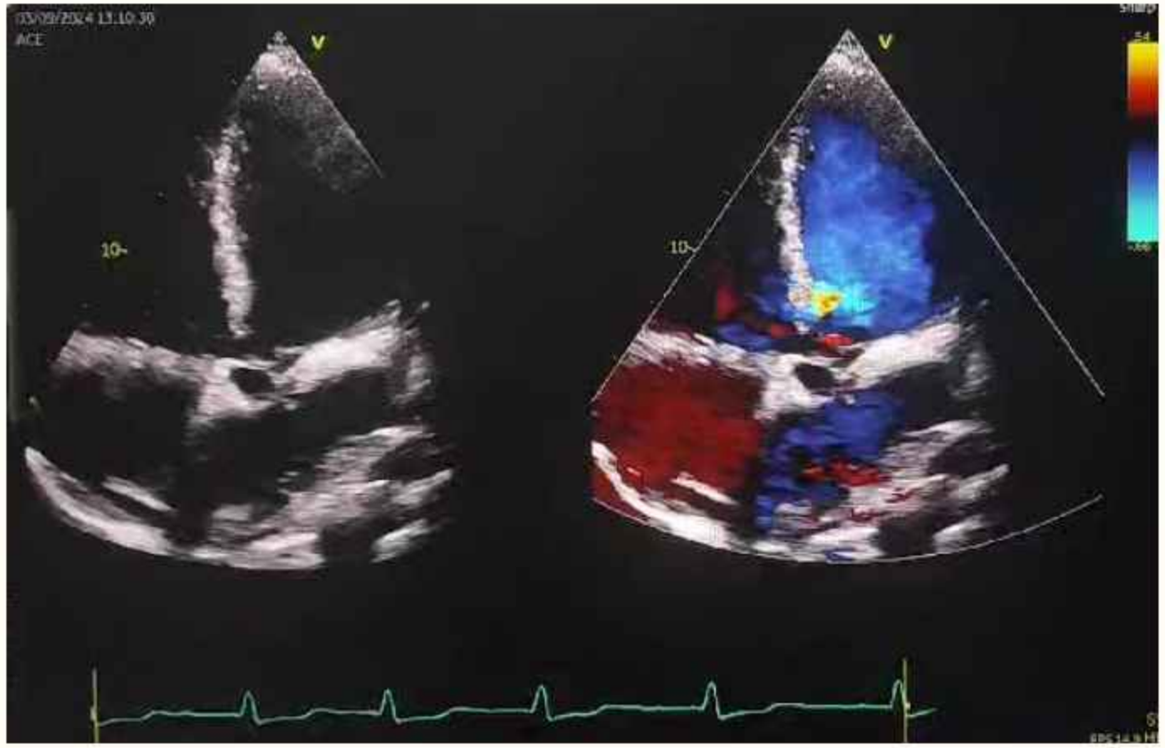
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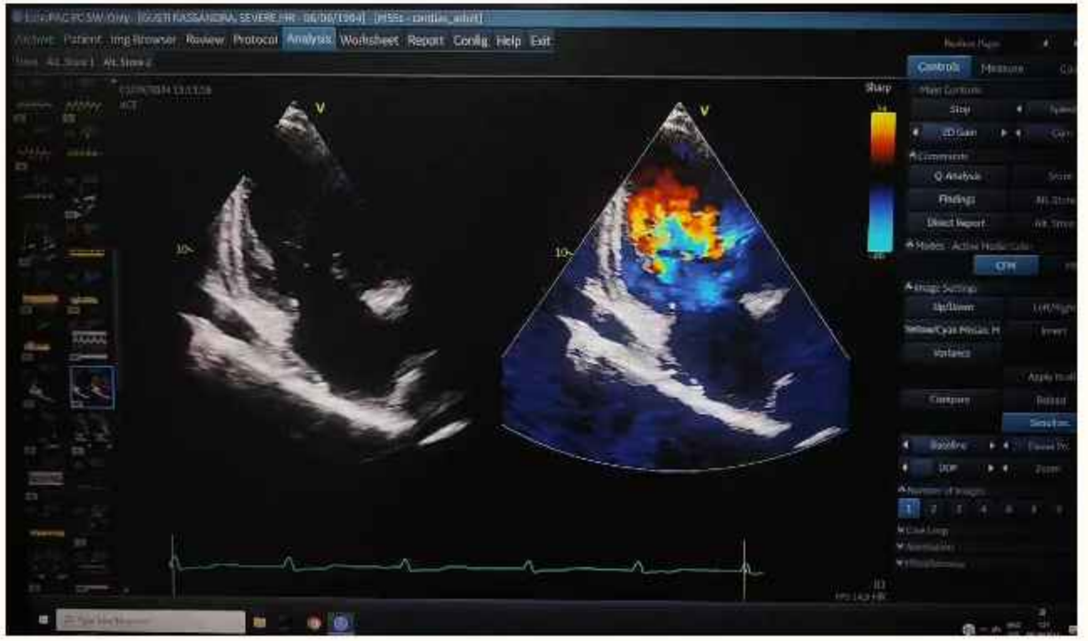

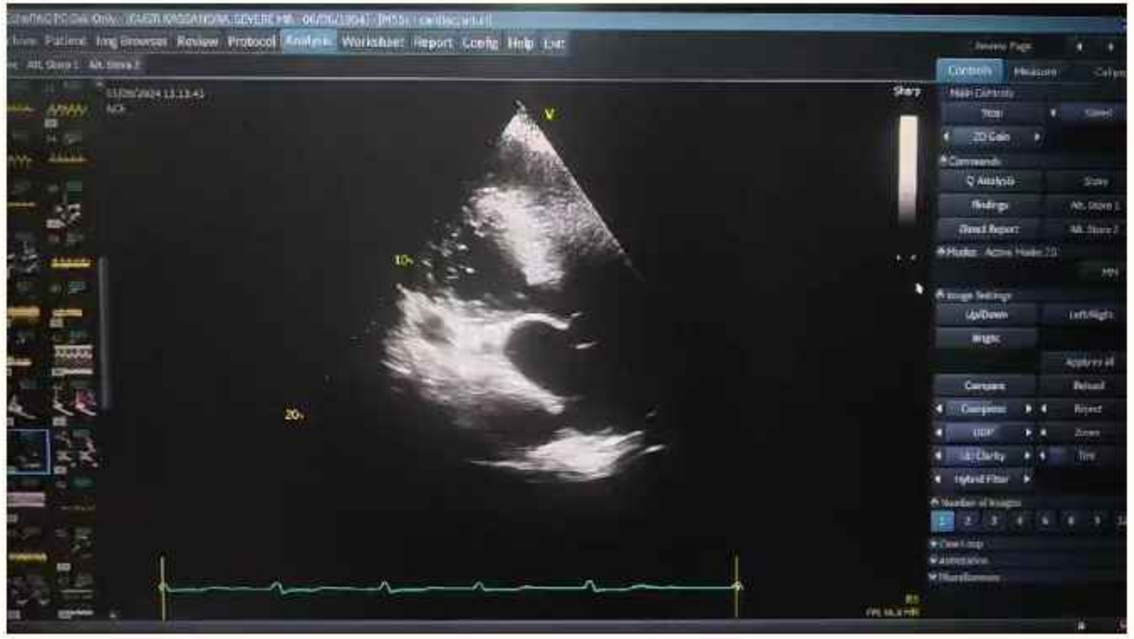

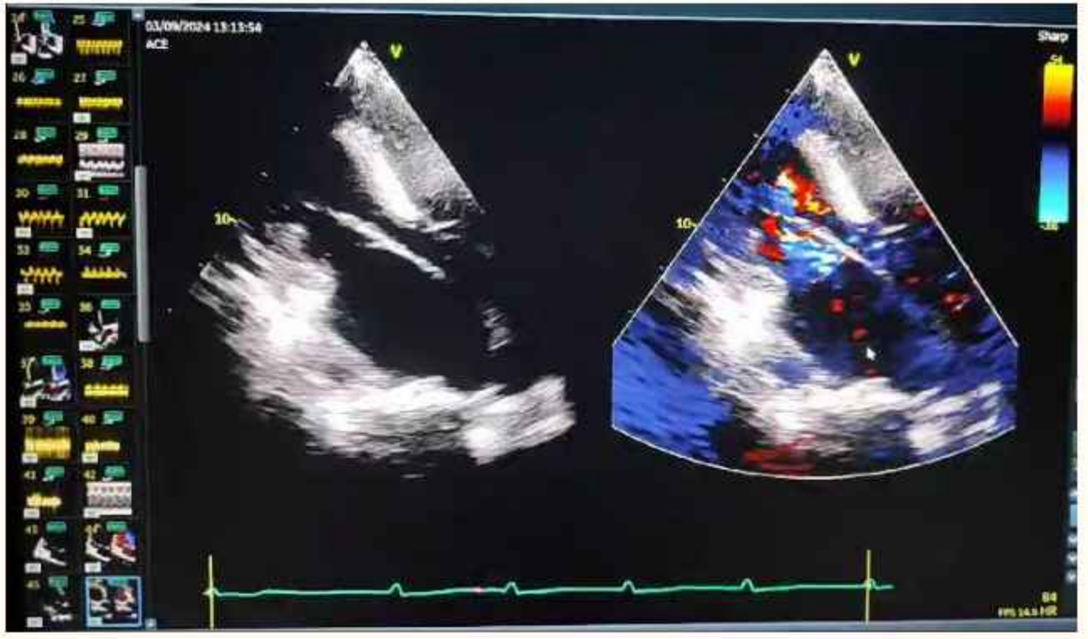
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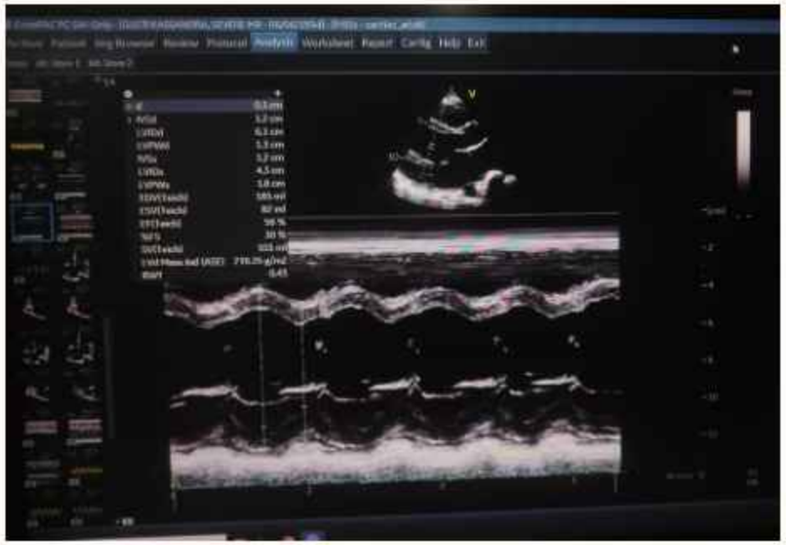
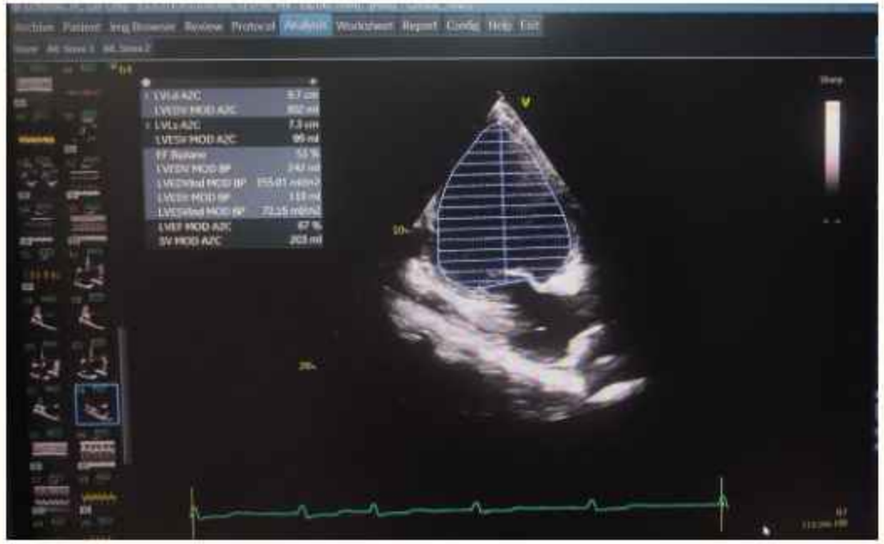
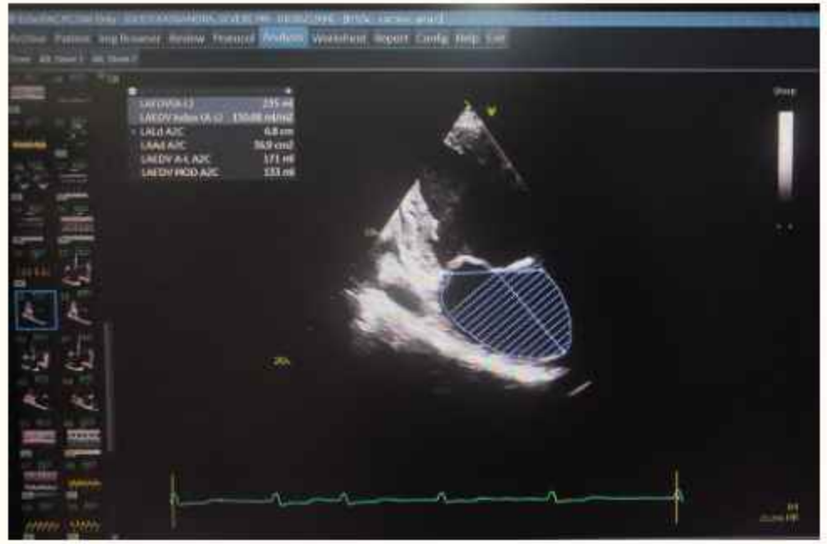
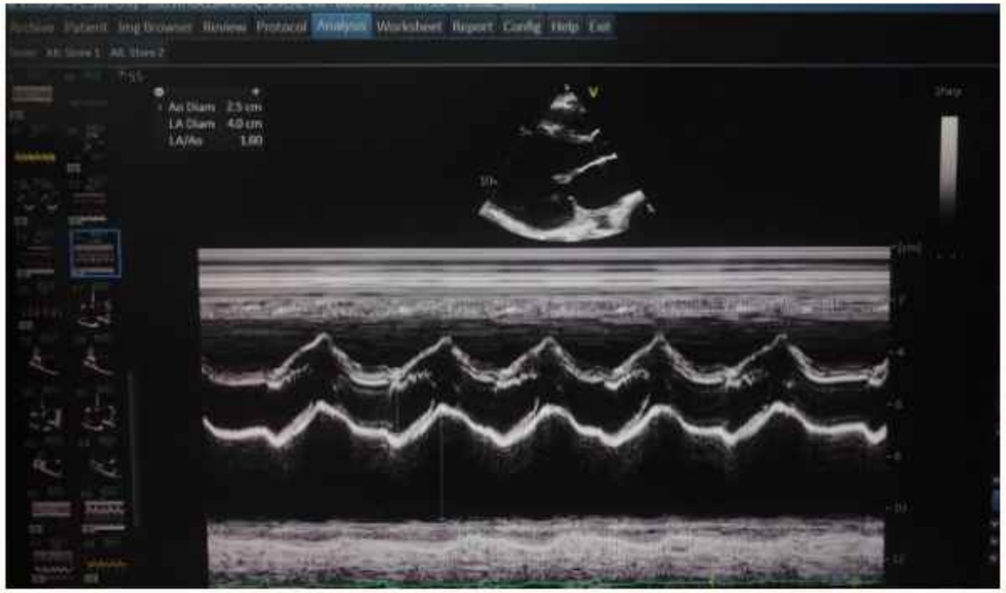
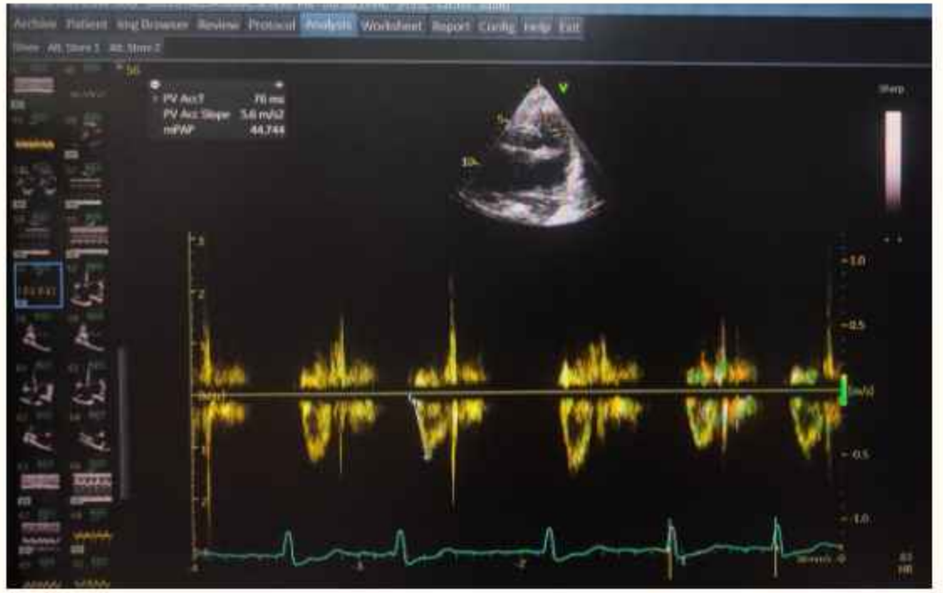
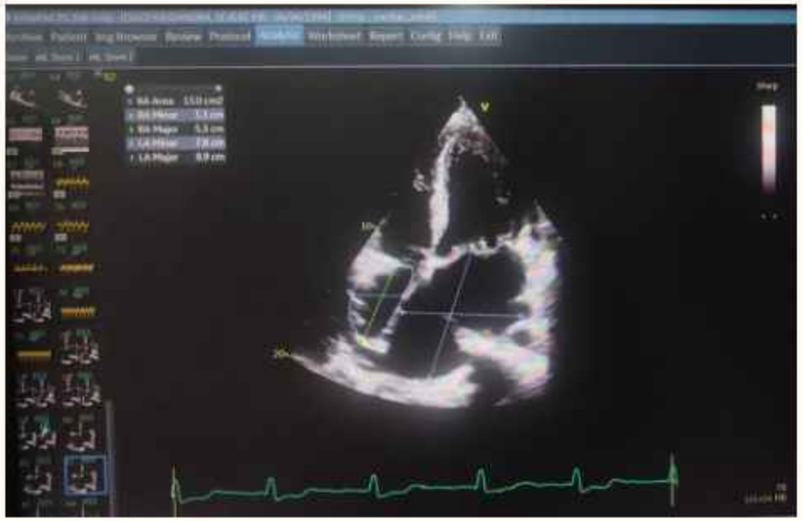


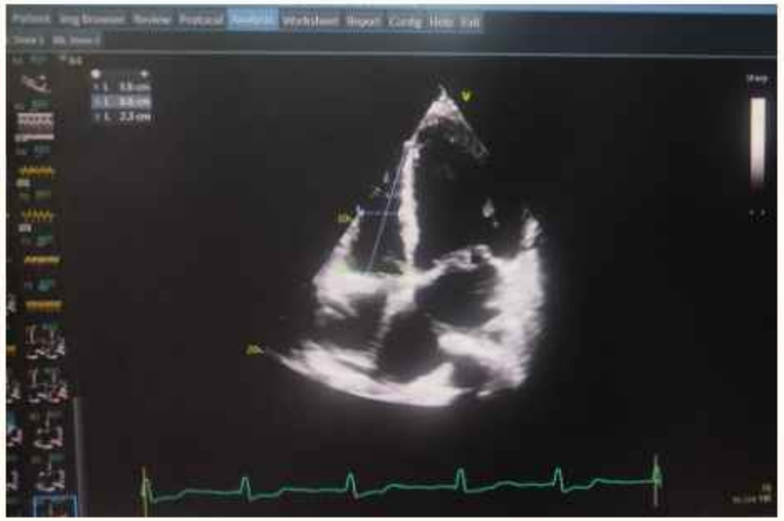


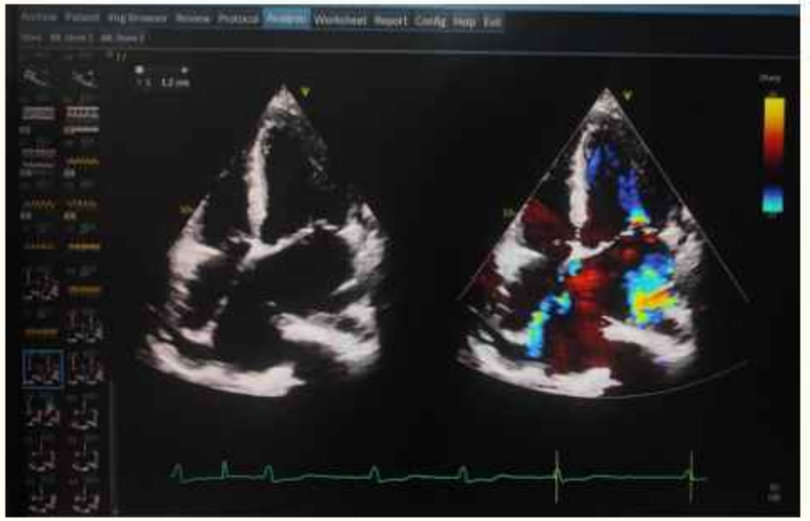


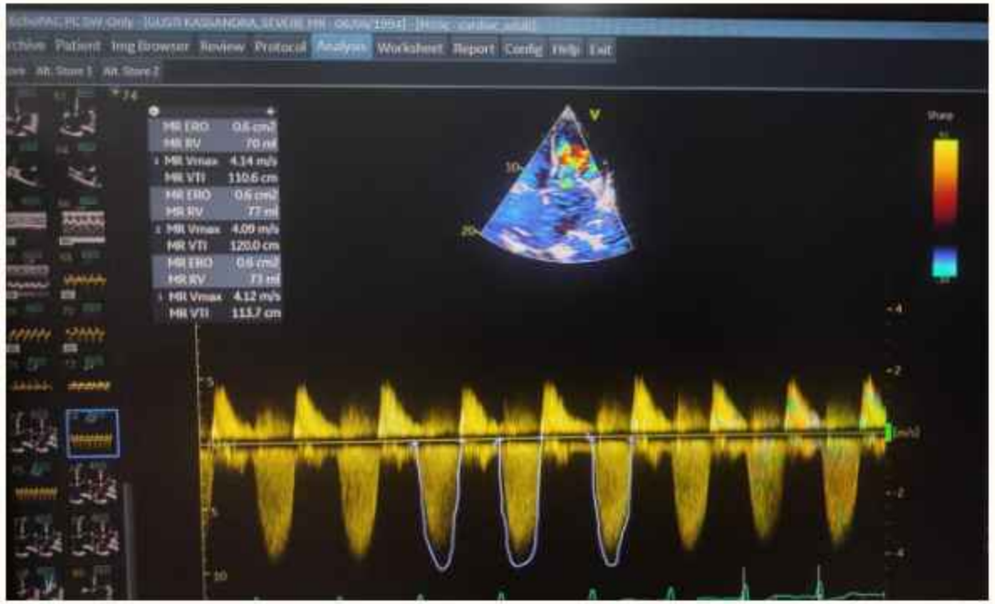


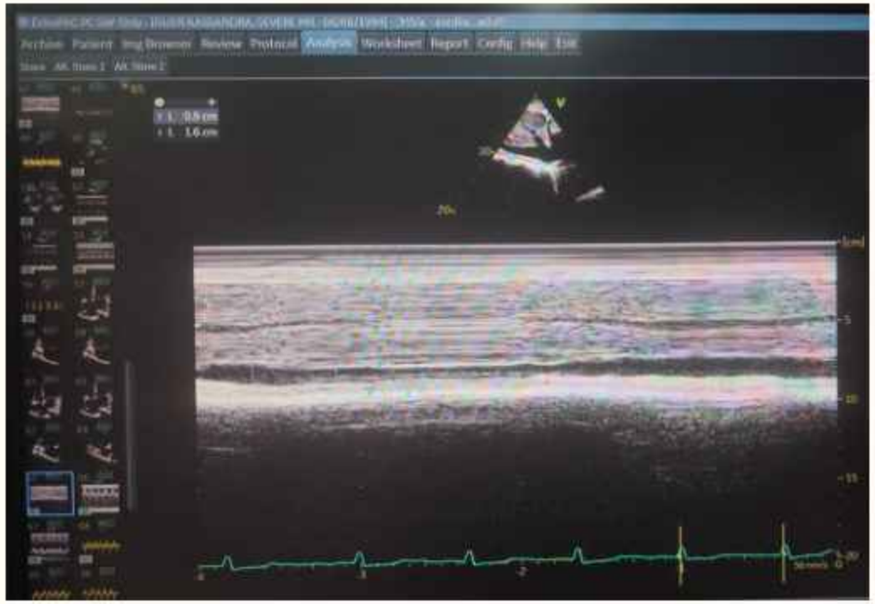








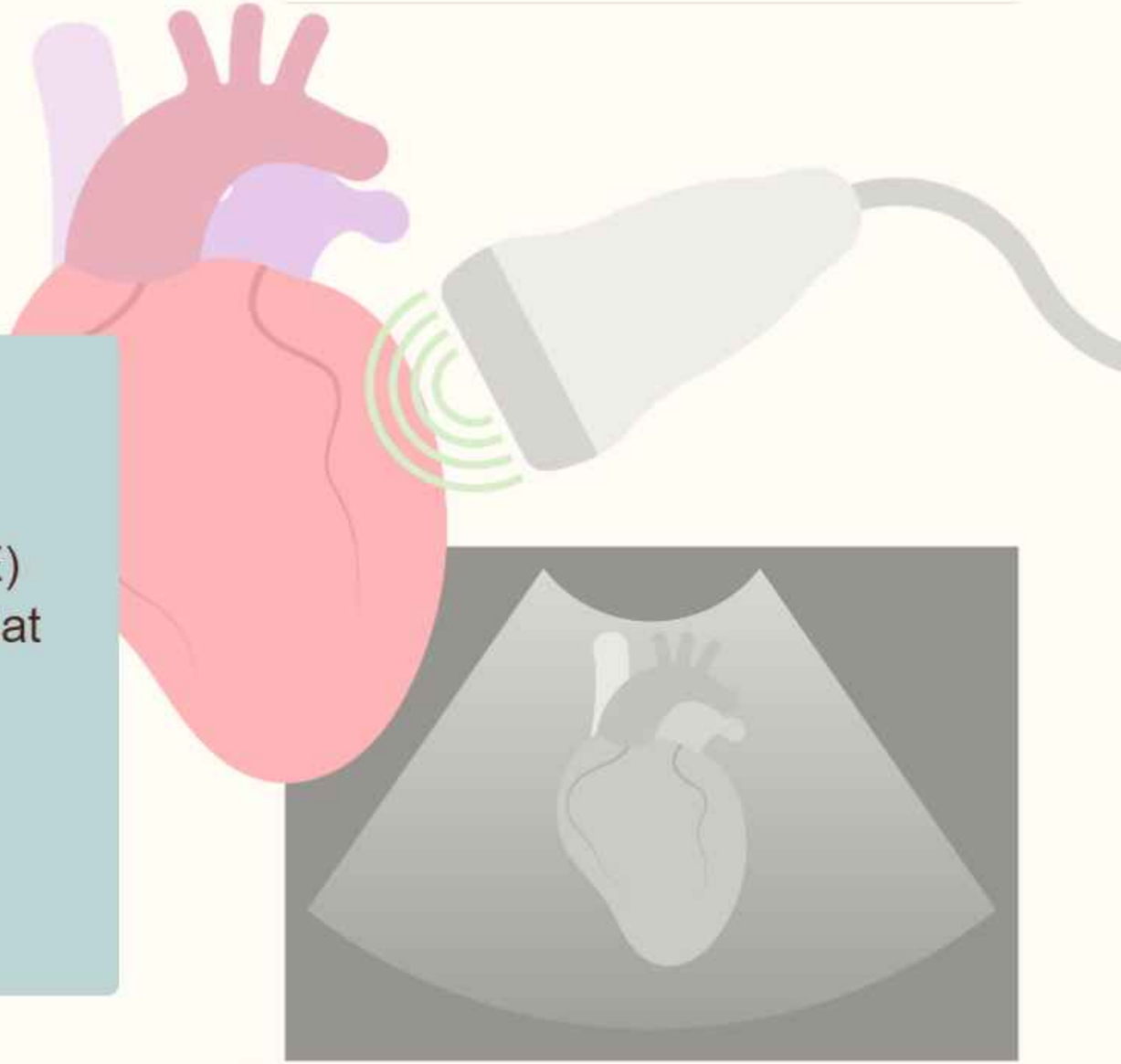

MR ERO 0.6 cm2
MR RV 70 ml
MR Vmax 4.14 m/s
MR VTI 110.6 cm
MR ERO 0.6 cm2
MR RV 77 ml
MR Vmax 4.09 m/s
MR VTI 120.0 cm
MR ERO 0.6 cm2
MR RV 73 ml
MR Vmax 4.12 m/s
MR VTI 111.7 cm



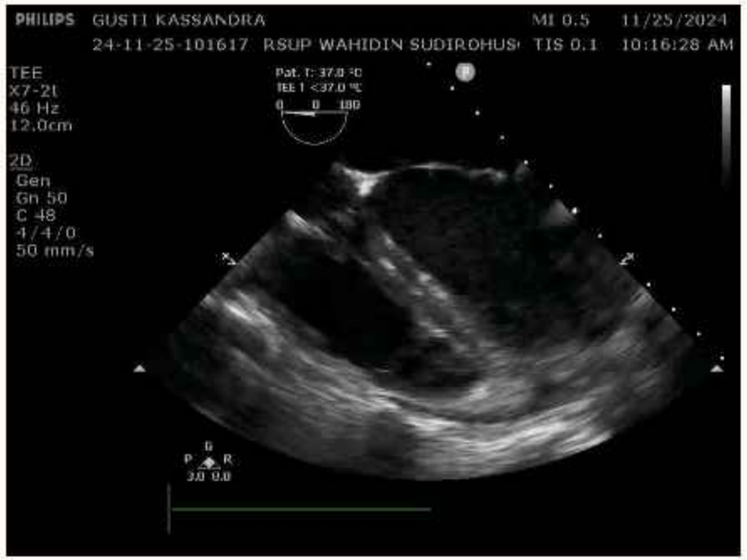
TRANSTHORACAL ECHOCARDIOGRAPHY PRE-OP

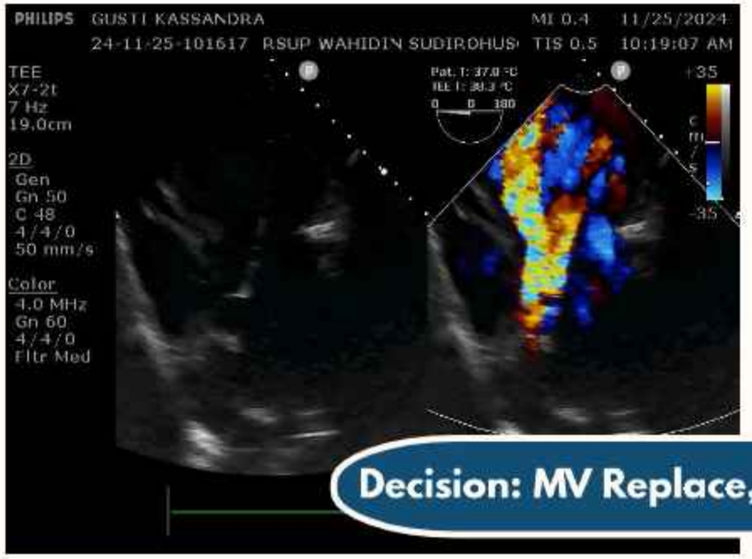
Examination on Atrial Fibrillation

- Severe Mitral Regurgitation due to RHD
- Mild Aortic Regurgitation
- Normal LV Systolic Function, EF 53% (BIPLANE)
- Normal RV Systolic Function, TAPSE 2.2 cm, S'lat 12 cm/s
- LA, LV Dilatation
- Eccentric LVH
- Global Normokinetic
- E/A on AF



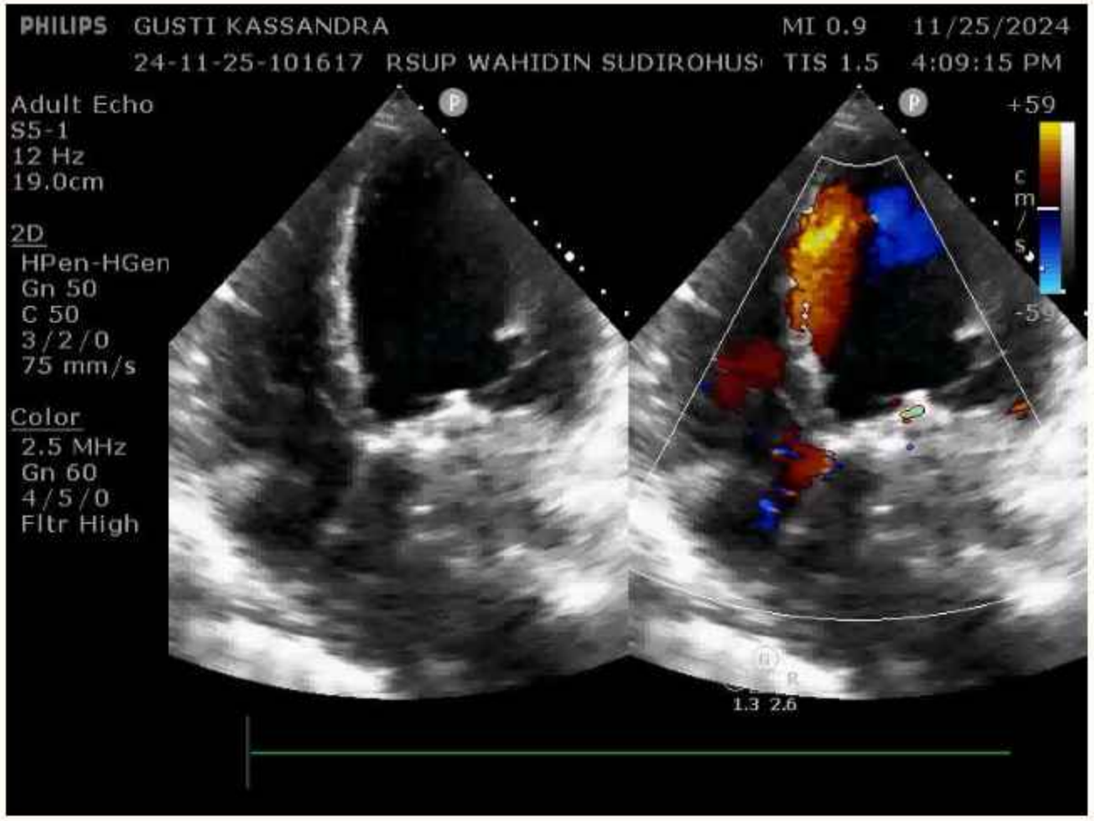
TRANSESOPHAGEAL ECHOCARDIOGRAPHY INTRA-OP

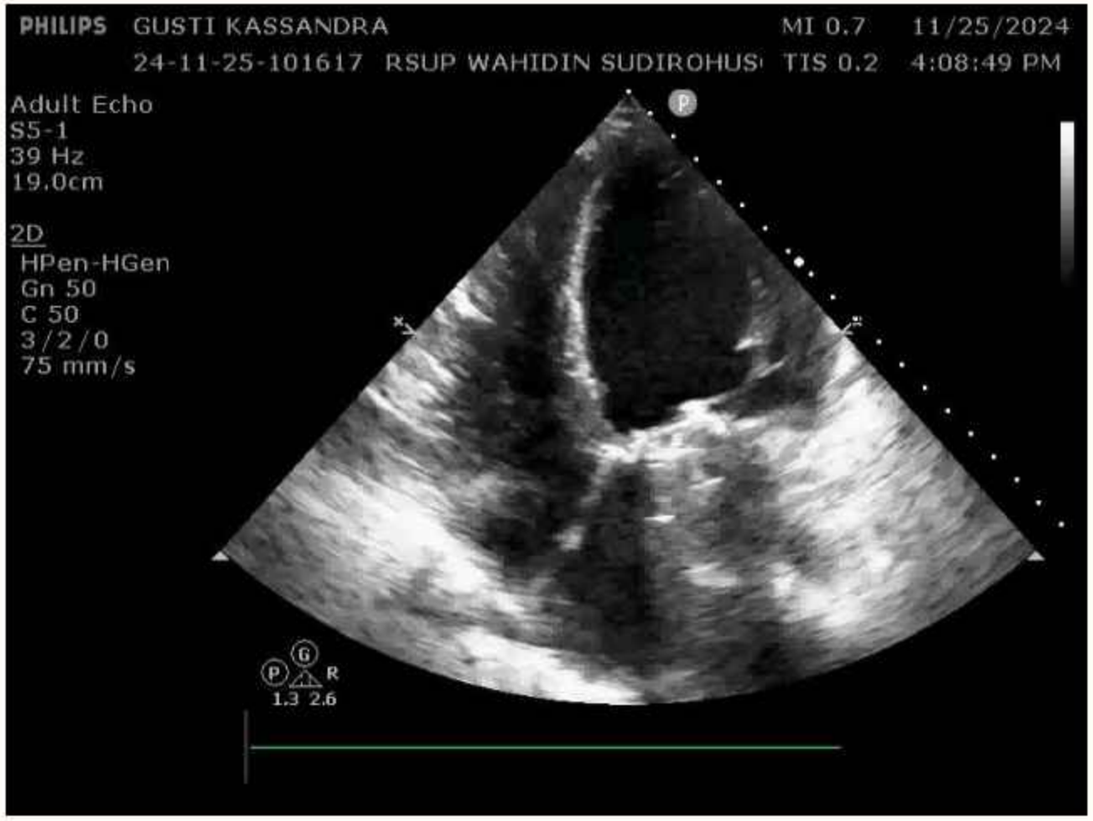




Decision: MV Replace, AV Replace, TV Repair

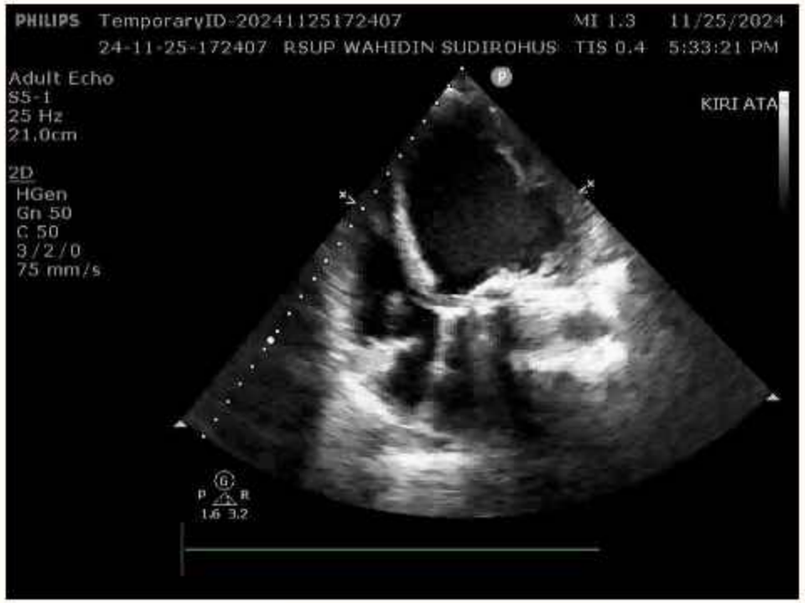
TRANSTHORACAL ECHOCARDIOGRAPHY POST-OP





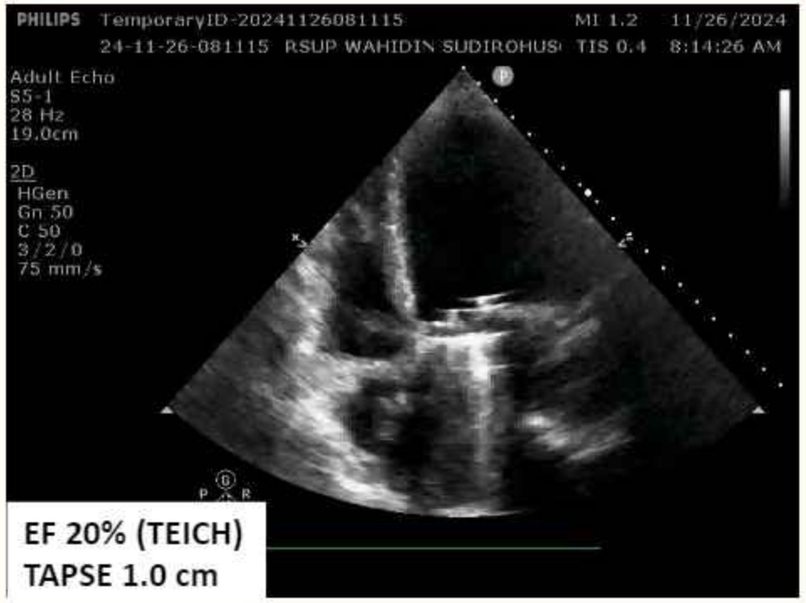
Aortic cross-clamp (AOX) time: 140 minutes
Cardiopulmonary bypass (CPB) time: 166 minutes

TRANSTHORACAL ECHOCARDIOGRAPHY POST-OP PERIODIC EVALUATION



1 Hour Post-Op

3 Hours Post-Op



EF 20% (TEICH)
TAPSE 1.0 cm

12 Hours Post-Op

Prosthetic Valve Evaluation:

Mitral:

- Adequate valve opening, no paravalvular leakage, washing jet mitral (+)
- DVI Mitral Pros. Valve 1.3
- EOA Mitral Pros. Valve 2.31 cm2

Aorta:

- Adequate valve opening, no paravalvular leakage, washing jet aortae (+)
- DVI Aortic Pros. Valve 0.53
- EOA Aortic Pros. Valve 1.67 cm2

Echo hemodynamic

- BP : 72/53 mmHg (60)
- HR : 60 bpm
- LVOT diam 2.0 cm
- LVOT VTI 19.8 cm
- LV SV 57.0 ml
- LV CO 3.18 l/min
- CVP 15 mmHg
- SVR 1132 dynes/sec/cm5

Understanding Low Cardiac Output Syndrome

Definition

LCOS is characterized by the heart's inability to pump sufficient blood to meet the body's metabolic needs, resulting in tissue hypoperfusion.

Clinical Presentation

Symptoms include persistent hypotension, oliguria, cold extremities, and prolonged capillary refill time.

Incidence

LCOS occurs in 5-15% of mitral valve replacements and up to 20% of aortic valve replacements.

Impact

LCOS leads to increased morbidity, prolonged mechanical ventilation, and higher mortality rates.

Easterwood, R.M., Bostock, I.C., Nammalwar, S., McCullough, J.N., Iribarne, A., 2018. The evolution of minimally invasive cardiac surgery: from minimal access to transcatheter approaches. Future Cardiol 14, 75–87.
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Risk Factors for Low Cardiac Output Syndrome

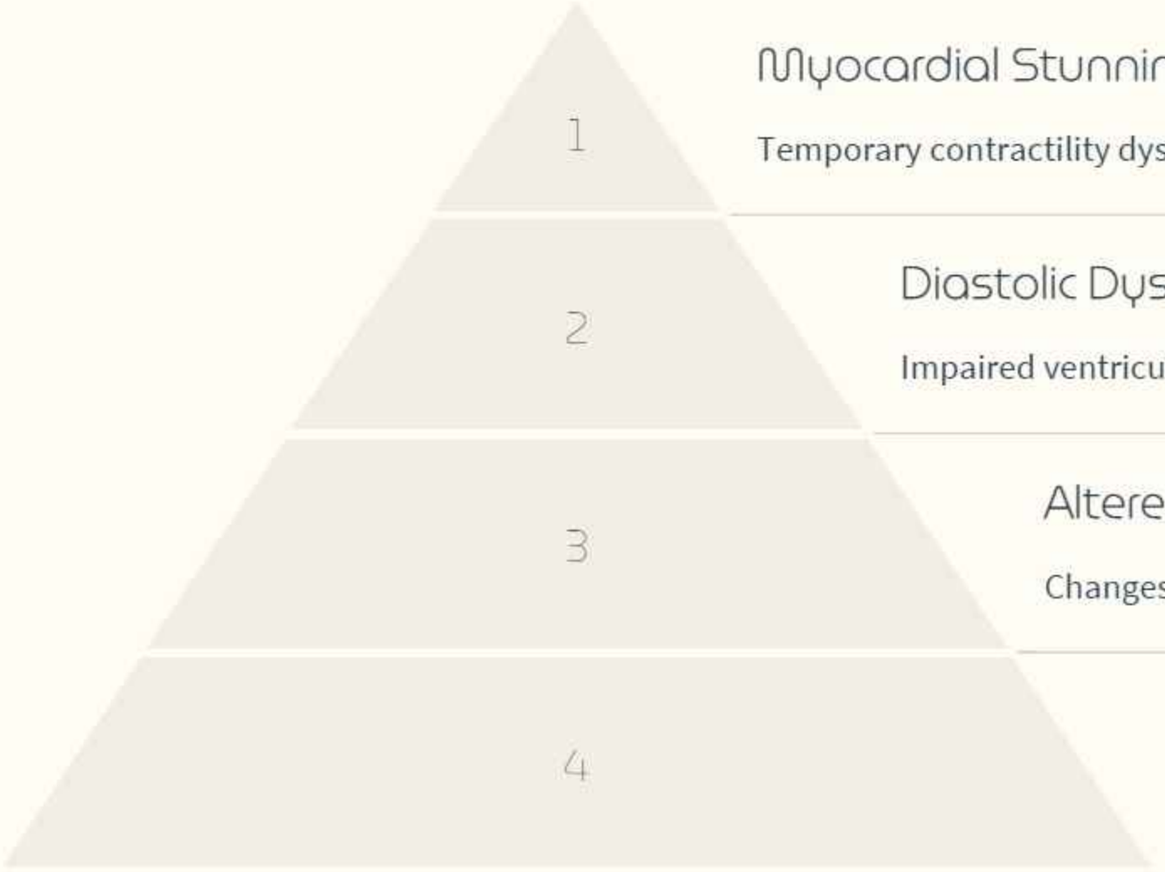
Predictors and Risk Factors of Postoperative LCOS

Preoperative factors	Age > 65 years[16,17]
	LVEF < 50%[16,17]
	On-pump CABG[17]
	DM and CKD[18,19]
	Malnutrition[20]
Intraoperative factors	CPB duration[16]
	Emergency surgery[17]
	Incomplete revascularization[17]
Laboratory predictors	Hemoglobin[21]
	TLC < 2,000 cells per microliter[22]
	NT-proBNP[23]
	BNP[24,25]
	hFABP[26]

Abbreviations: BNP, brain natriuretic peptide; CABG, coronary artery bypass grafting; CKD, chronic kidney disease; CPB, coronary artery bypass; DM, diabetes mellitus; hFABP, heart fatty acid binding protein; LVEF, left ventricular ejection fraction; NT-proBNP, N-terminal of the prohormone brain natriuretic peptide; TLC, total lymphocyte count.

Lomivorotov, V. V, Efremov, S.M., Kirov, M.Y., Fominskiy, E. V, Karaskov, A.M., 2017. Low-cardiac-output syndrome after cardiac surgery. J Cardiothorac Vasc Anesth 31, 291–308.

Pathophysiology of Low Cardiac Output Syndrome



Myocardial Stunning

Temporary contractility dysfunction due to ischemia/reperfusion injury

Diastolic Dysfunction

Impaired ventricular filling and compliance

Altered Loading Conditions

Changes in preload and afterload affecting cardiac performance

Right Ventricular Dysfunction

Increased pulmonary vascular resistance and RV dilatation

These factors contribute to reduced cardiac output, leading to tissue hypoperfusion and potential organ dysfunction if not addressed promptly.

Easterwood, R.M., Bostock, I.C., Nammalwar, S., McCullough, J.N., Iribarne, A., 2018. The evolution of minimally invasive cardiac surgery: from minimal access to transcatheter approaches. Future Cardiol 14, 75–87.
Hancock, H.C., Maier, R.H., Kaslm, A., Mason, J., Murphy, G., Goodwin, A., Owens, W.A., Akowuah, E., 2021. Mini-sternotomy versus conventional sternotomy for aortic valve replacement: a randomised controlled trial. BMJ Open 11, e041396.
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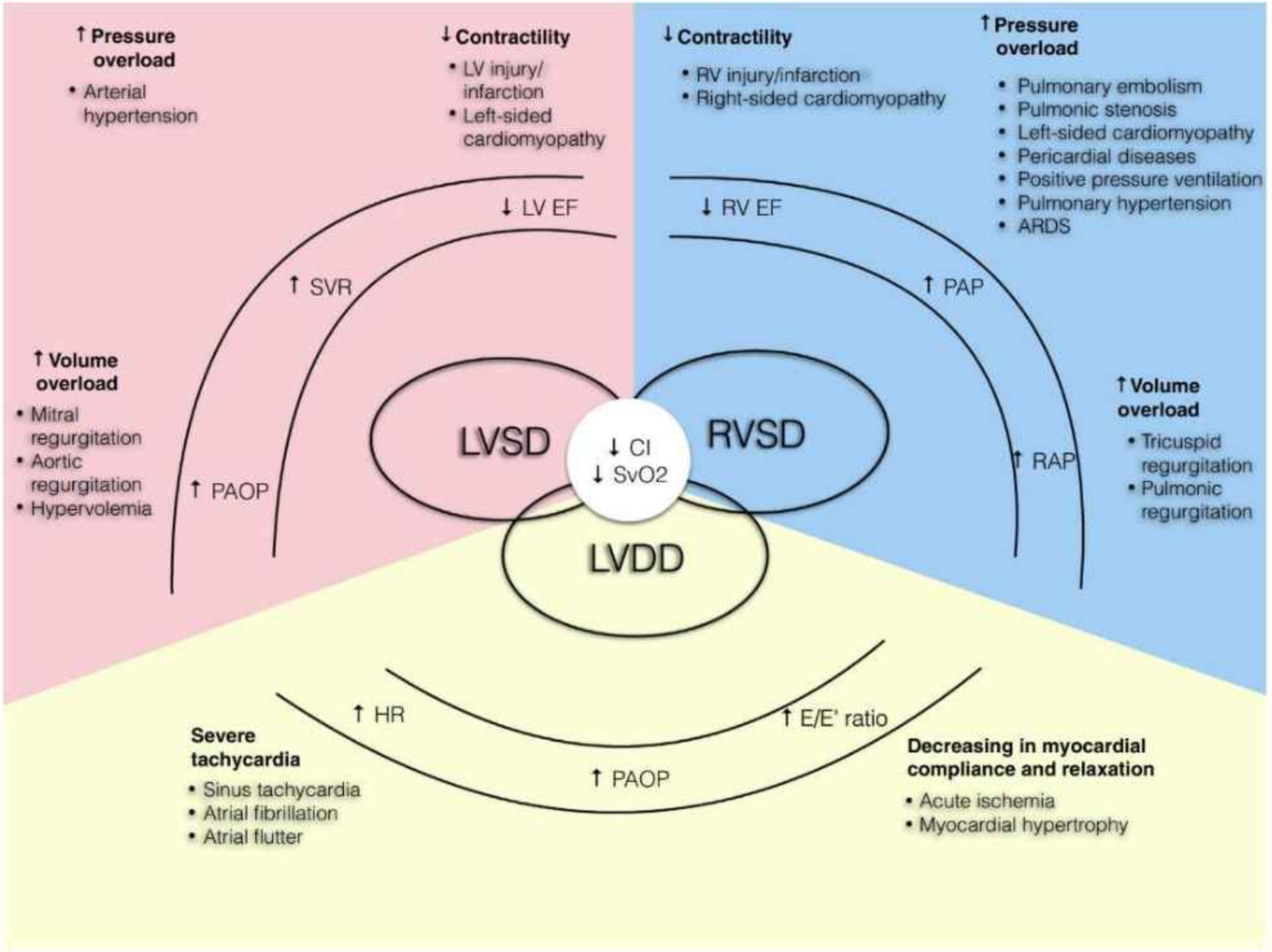
Pathophysiology of Low Cardiac Output Syndrome



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Diagnostic Parameters for LCOS

Clinical Signs

- Hypotension (BP < 90/60 mmHg)
- Oliguria (< 0.5 mL/kg/hour)
- Cold extremities

Echocardiography

- Reduced EF (< 30%)
- Decreased TAPSE (< 1.5 cm)
- Wall motion abnormalities

Hemodynamic Parameters

- Cardiac output < 4 L/min
- Cardiac index < 2.2 L/min/m^2
- Elevated CVP (> 12 mmHg)

Malaisrie, S.C., Barnhart, G.R., Farivar, R.S., Mehall, J., Hummel, B., Rodriguez, E., Anderson, M., Lewis, C., Hargrove, C., Attawadi, G., 2014. Current era minimally invasive aortic valve replacement: techniques and practice. J Thorac Cardiovasc Surg 147, 6–14.

Management of Low Cardiac Output Syndrome

1

Optimize Volume Status

Assess and correct fluid balance to ensure adequate preload.

2

Inotropic Support

Administer agents like dobutamine or milrinone to improve cardiac contractility.

3

Vasopressor Therapy

Use norepinephrine or vasopressin to maintain adequate perfusion pressure.

4

Mechanical Support

Consider IABP or ECMO for refractory cases.

Modi, P., Hassan, A., Chitwood Jr, W.R., 2008. Minimally invasive mitral valve surgery: a systematic review and meta-analysis. European Journal of Cardio-Thoracic Surgery 34, 943–952.
Lomivorotov, V. V, Efremov, S.M., Kirov, M.Y., Fominskiy, E. V, Karaskov, A.M., 2017. Low-cardiac-output syndrome after cardiac surgery. J Cardiothorac Vasc Anesth 31, 291–308.

Pharmacological Interventions in LCOS

Drug Class	Examples	Mechanism	Considerations
Inotropes	Dobutamine, Milrinone	Increase cardiac contractility	May increase myocardial oxygen demand
Vasopressors	Norepinephrine, Vasopressin	Maintain blood pressure	Monitor for peripheral vasoconstriction
Vasodilators	Nitroprusside, Nitroglycerin	Reduce afterload	Use cautiously in hypotension
Lusitropes	Levosimendan	Improve myocardial relaxation	Limited availability in some regions

Modi, P., Hassan, A., Chitwood Jr, W.R., 2008. Minimally invasive mitral valve surgery: a systematic review and meta-analysis. European Journal of Cardio-Thoracic Surgery 34, 943–952.
Lomivorotov, V. V, Efremov, S.M., Kirov, M.Y., Fominskiy, E. V, Karaskov, A.M., 2017. Low-cardiac-output syndrome after cardiac surgery. J Cardiothorac Vasc Anesth 31, 291–308.

Mechanical Circulatory Support in LCOS

Intra-Aortic Balloon Pump (IABP)

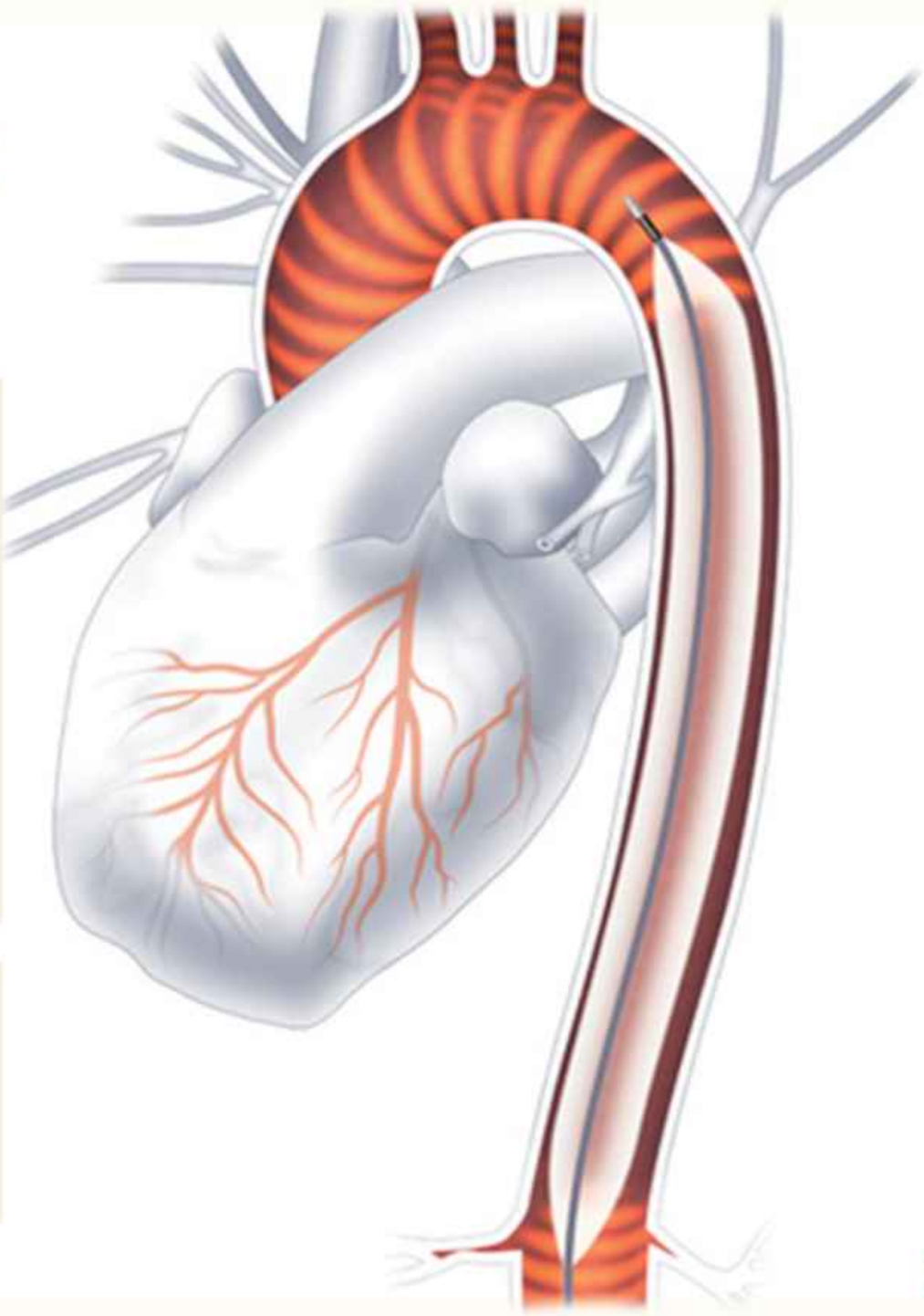
Enhances coronary perfusion and reduces left ventricular afterload. Suitable for short-term support in less severe cases of LCOS.

Extracorporeal Membrane Oxygenation (ECMO)

Provides both cardiac and respiratory support. Used in severe, refractory LCOS cases where conventional therapies have failed.

Ventricular Assist Devices (VADs)

Offer longer-term support for ventricular dysfunction. Can be used as a bridge to recovery, transplant, or destination therapy.



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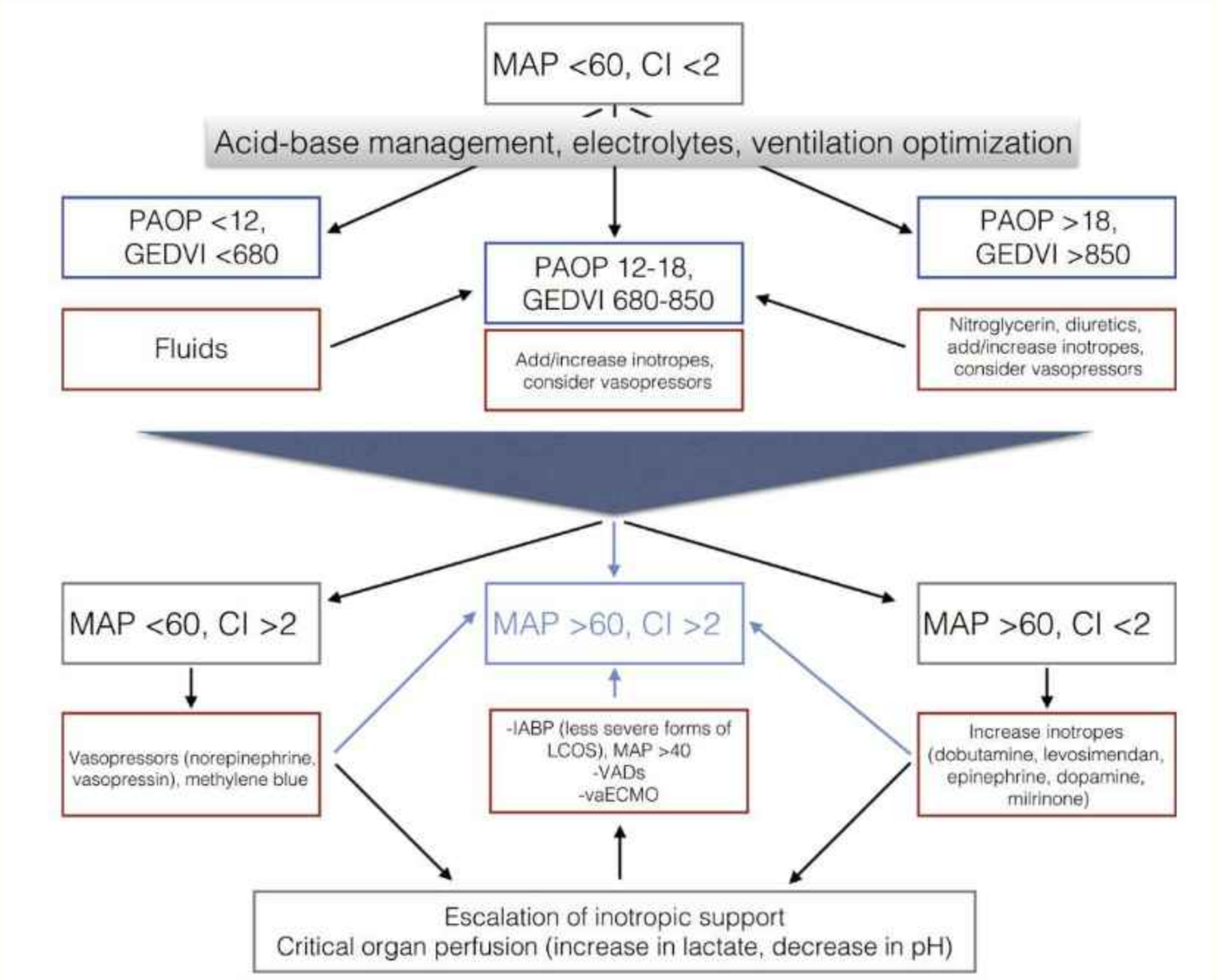
Management Algorithm in LCOS



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Monitoring and Follow-up in LCOS

1

Continuous Hemodynamic Monitoring

Regular assessment of blood pressure, cardiac output, and mixed venous oxygen saturation.

2

Serial Echocardiography

Evaluate ventricular function, valvular performance, and response to therapy.

3

Laboratory Tests

Monitor lactate levels, organ function markers, and electrolyte balance.

4

Long-term Follow-up

Regular outpatient visits to assess cardiac function and optimize medical therapy.

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THANK YOU