# Hemodynamic Highlights for the Boards

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# Disclosures

None

# Objectives

Basics

High yield cases

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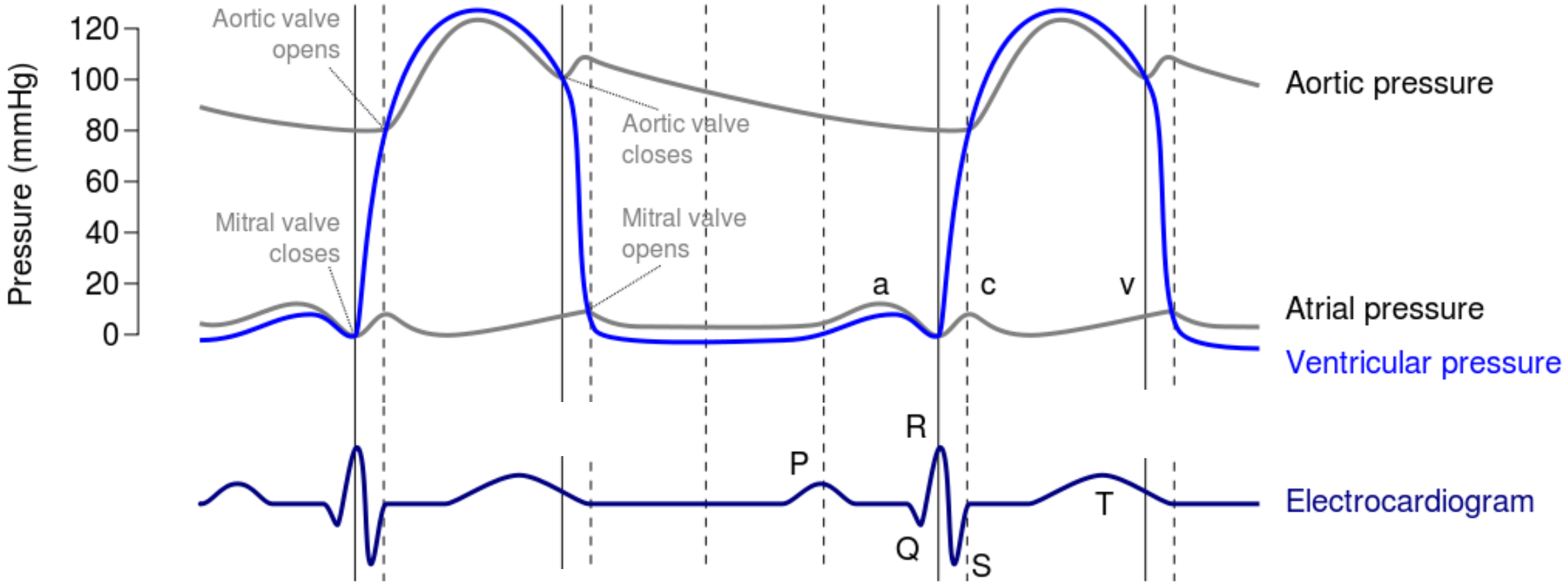
**Basics**

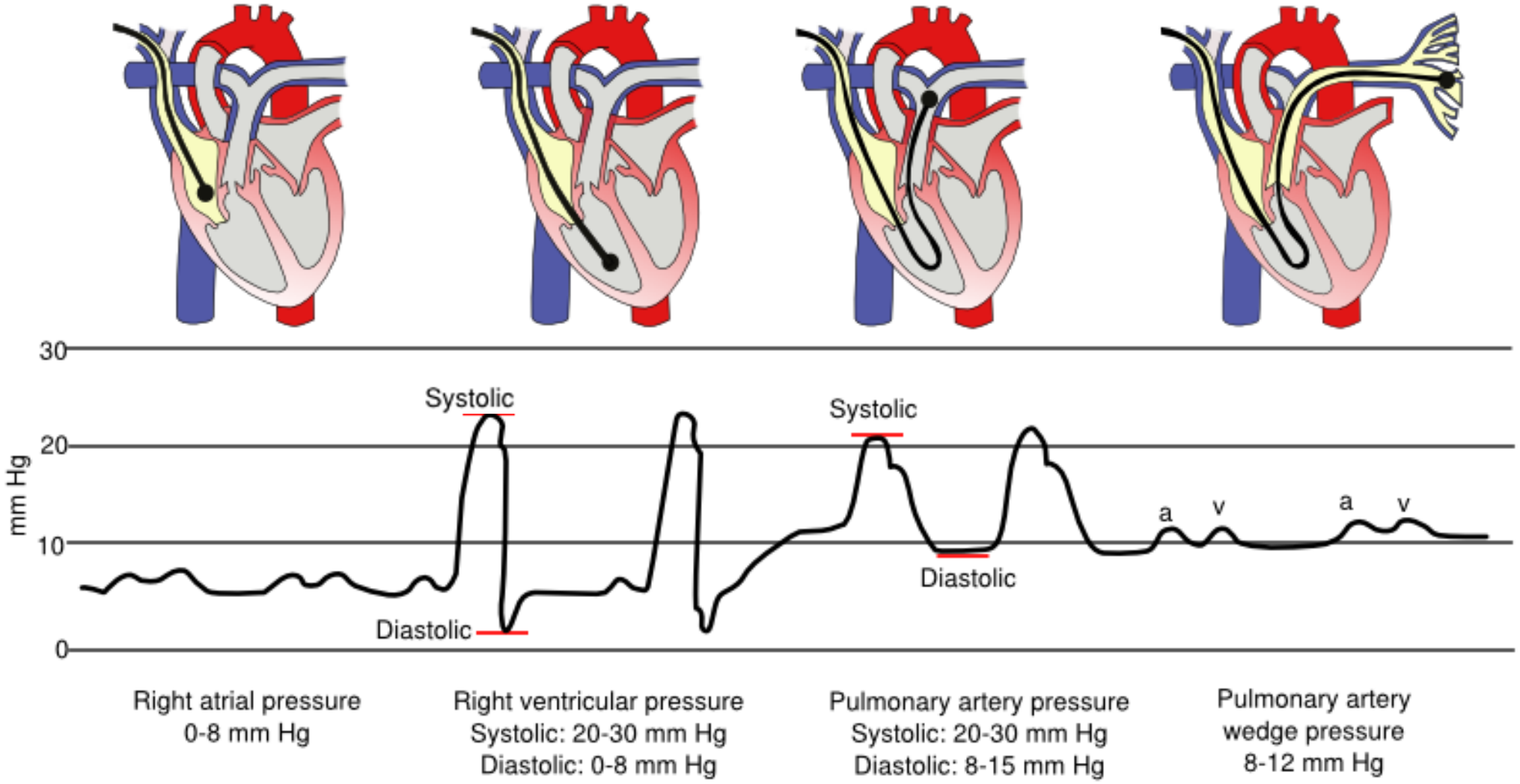
High yield cases

# Flashback to medical school…



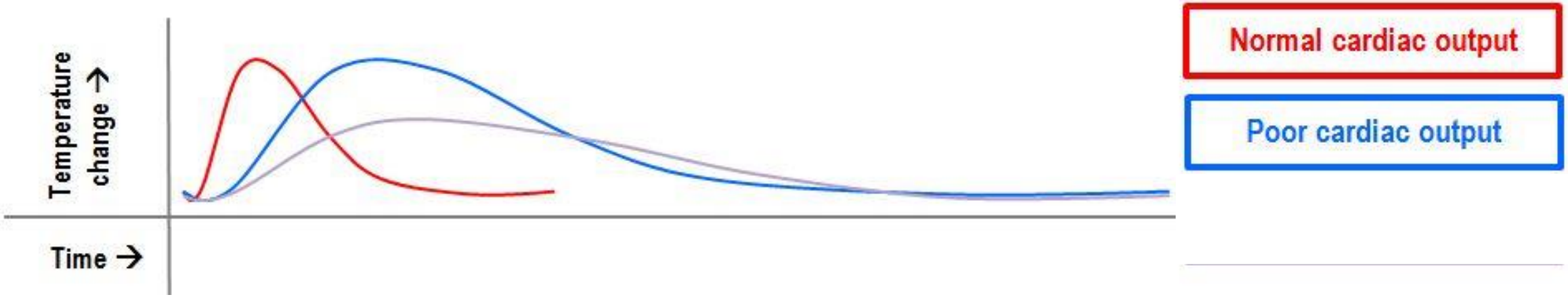

https://commons.wikimedia.org/wiki/File:Wiggers_Diagram.svg

# Get the pressures




http://www.pcipedia.org/wiki/File:RightHeart_Waveforms_Fig1.svg

# Get the output




Fick CO = <u>VO2 (oxygen consumption)</u>

Arteriovenous [O2] difference → **Hgb** and (AoO2% – **PAO2%**)

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https://derangedphysiology.com/main/cicm-primary-exam/required-reading/cardiovascular-system/Chapter%20813/thermodilution-measurement-cardiac-output-pulmonary-artery-catheter

# Key equations

Resistance = Pressure gradient / Blood flow

SVR = (MAP – RAP) / CO

PVR = (mPAP – PCWP) / CO

Qp/Qs (based on Fick) = (Aortic sat – **MV sat**) / (PV sat – PA sat)

Gorlin: Valve area = $\frac{\text{systolic or diastolic flow rate}}{k*\sqrt{(MPG)}}$ → **CO/[(SEP or DFP)*HR]**

Hakki: Valve area = $\frac{CO}{\sqrt{(\text{peak-to-peak pressure})} \text{ OR } \sqrt{(MPG)}}$

# Objectives

Basics

**High yield cases**

# Undifferentiated shock → what type?

| Scenario | RA | PA | PCW | PVR | SVR | CO/CI |
|---|---|---|---|---|---|---|
| 1 | 15 | 49/32 | 31 | 1.8 | 3600 | 4/1.9 |
| | | | | | | |
| | | | | | | |

# ANSWER: CLASSIC “COLD AND WET” CARDIOGENIC SHOCK

# Undifferentiated shock → what type?

| Scenario | RA | PA | PCW | PVR | SVR | CO/CI |
|---|---|---|---|---|---|---|
| 1 | 15 | 49/32 | 31 | 1.8 | 3600 | 4/1.9 |
| 2 | 2 | 25/10 | 10 | 1.3 | 1900 | 3.6/1.8 |
| | | | | | | |

# ANSWER: HYPOVOLEMIC SHOCK OR “COLD AND DRY” CARDIOGENIC SHOCK

# Undifferentiated shock → what type?

| Scenario | RA | PA | PCW | PVR | SVR | CO/CI |
|---|---|---|---|---|---|---|
| 1 | 15 | 49/32 | 31 | 1.8 | 3600 | 4/1.9 |
| 2 | 2 | 25/10 | 10 | 1.3 | 1900 | 3.6/1.8 |
| 3 | 16 | 49/32 | 31 | 1.8 | 600 | 4/1.7 |

# ANSWER: MIXED DISTRIBUTIVE AND CARDIOGENIC SHOCK

| Type | Preload | Cardiac Output | SVR | PA O2 Sat |
|---|---|---|---|---|
| Distributive | ↔ or ↓ | ↔ | ↓ | > 65% |
| Cardiogenic | ↑ | ↓ | ↑ | < 65% |
| Hypovolemic | ↓ | ↓ | ↑ | < 65% |
| Obstructive | variable | ↓ | ↑ | variable |

# Aortic valve area?

| | |
|---|---|
| RA | 12 mmHg |
| PA | 33/16 mmHg |
| PCW | 15 mmHg |
| CO | 6 L/min |

| | |
|---|---|
| Echo peak pressure gradient | 91 mmHg |
| Cath peak LV pressure | 150 mmHg |
| Cath peak aortic pressure | 101 mm Hg |

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**<u>Hakki</u>**

**AVA = CO/√(P-to-P)**

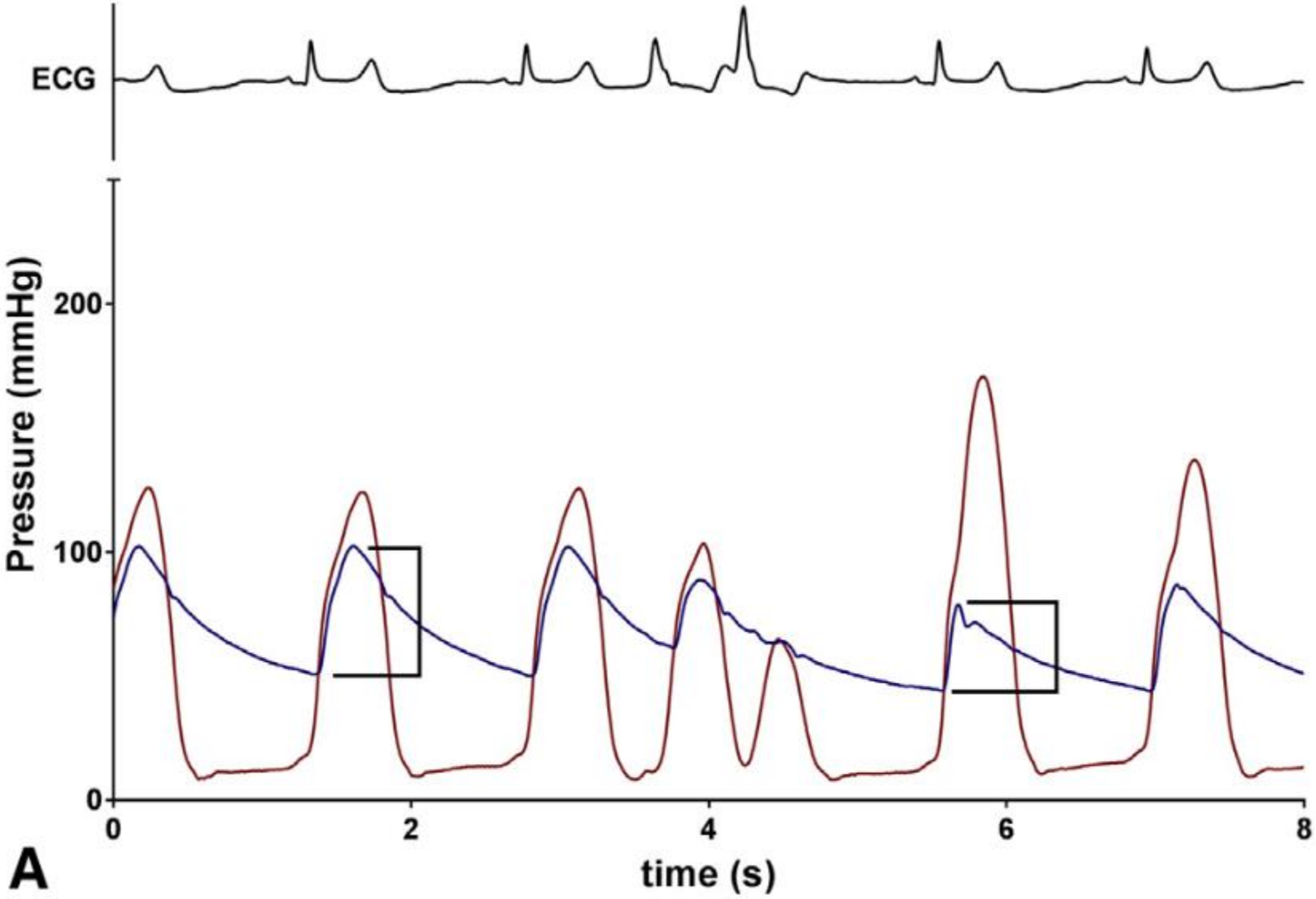
= 6 / √(150-101)

= 6 / √(49)

= 6 / 7

**= 0.86**

# Diagnosis?




Cui. JTCVS. 2018.

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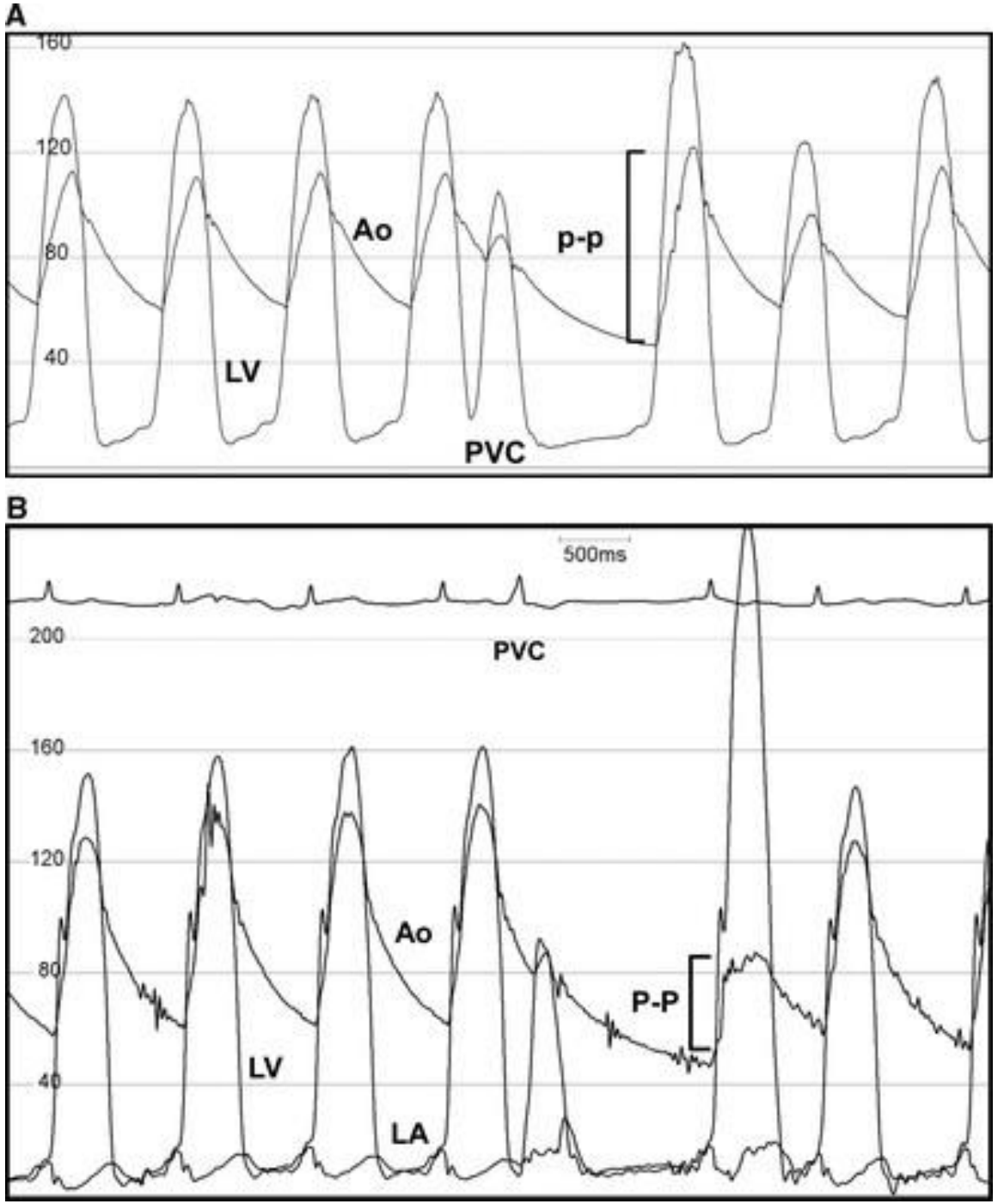
# ANSWER: OBSTRUCTIVE HCM (BROCKENBROUGH-BRAUNWALD-MORROW SIGN)




**Aortic stenosis**

**Hypertrophic cardiomyopathy**

Nishimura et al. Circ. 2012.

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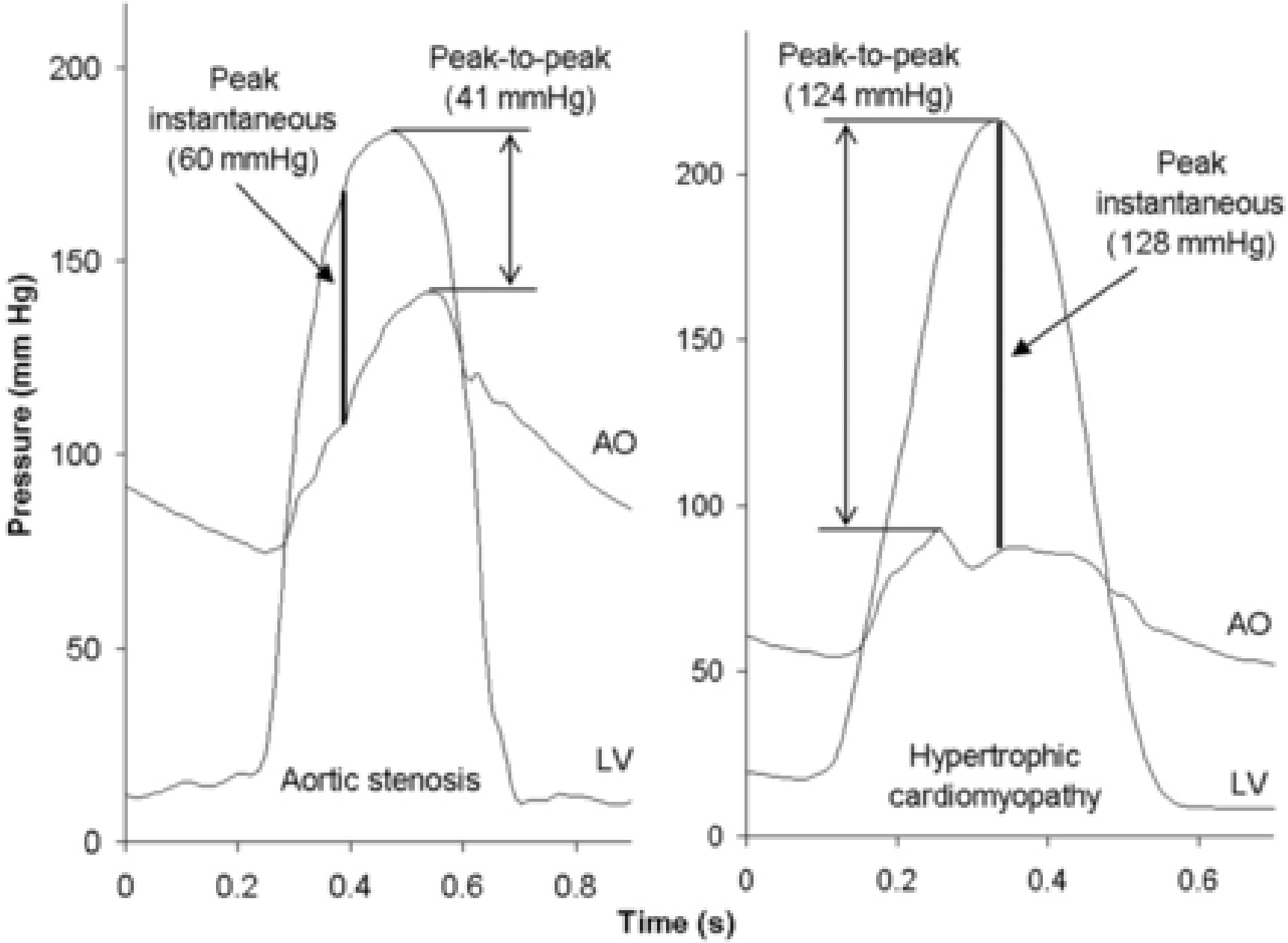


Geske et al. JACC: CV Interventions. 2012

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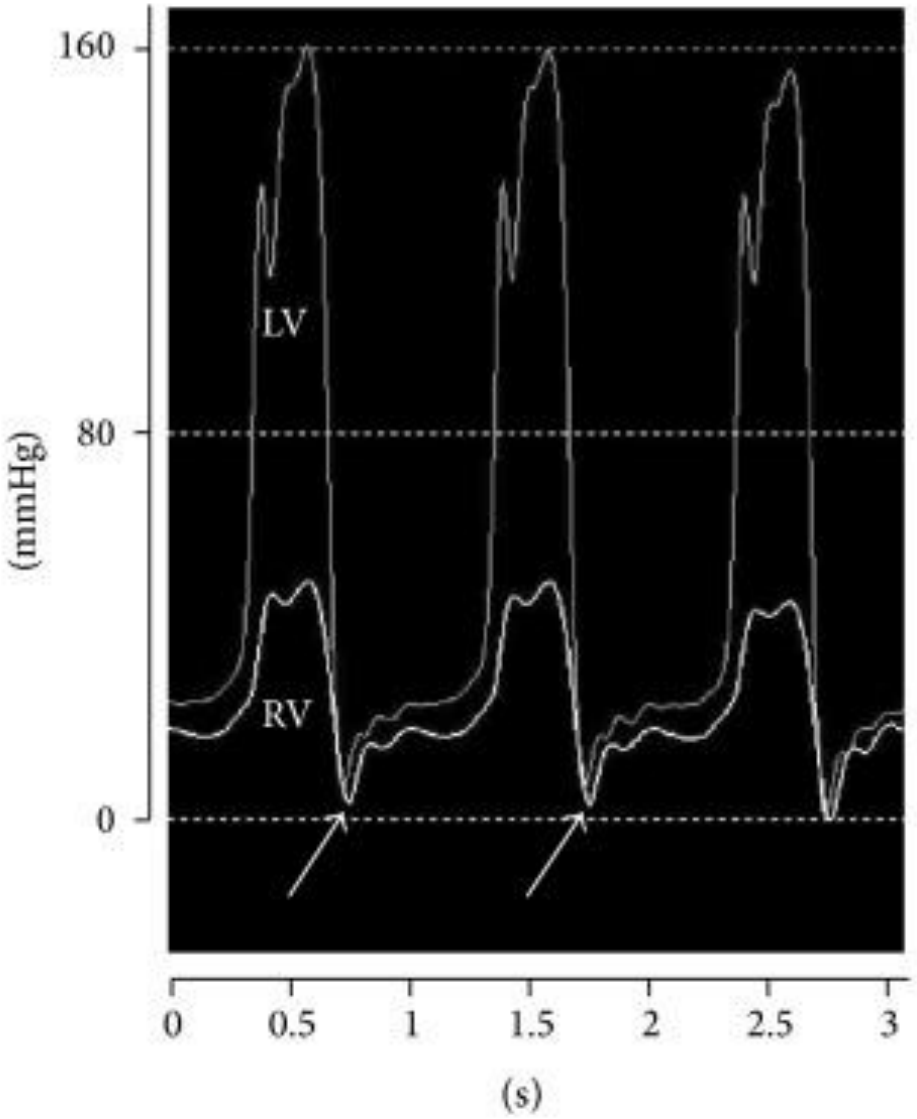
# Constriction or restriction?




Rivinius et al. Case Reports in Transplantation. 2015.

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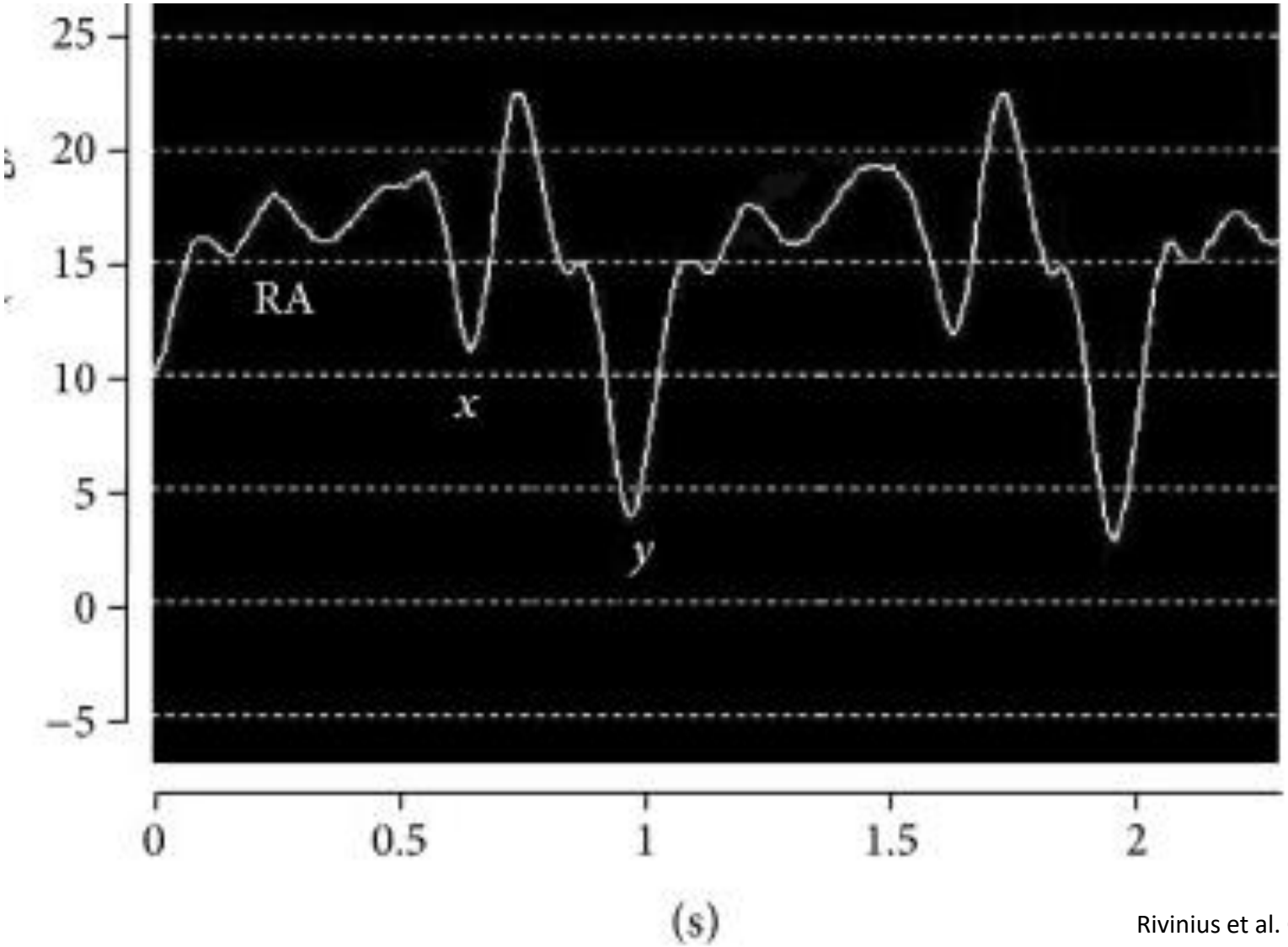
# ANSWER: CONSTRICTION AND RESTRICTION (SQUARE ROOT OR DIP AND PLATEAU SIGN)

# Constriction or restriction?




Rivinius et al. Case Reports in Transplantation. 2015.

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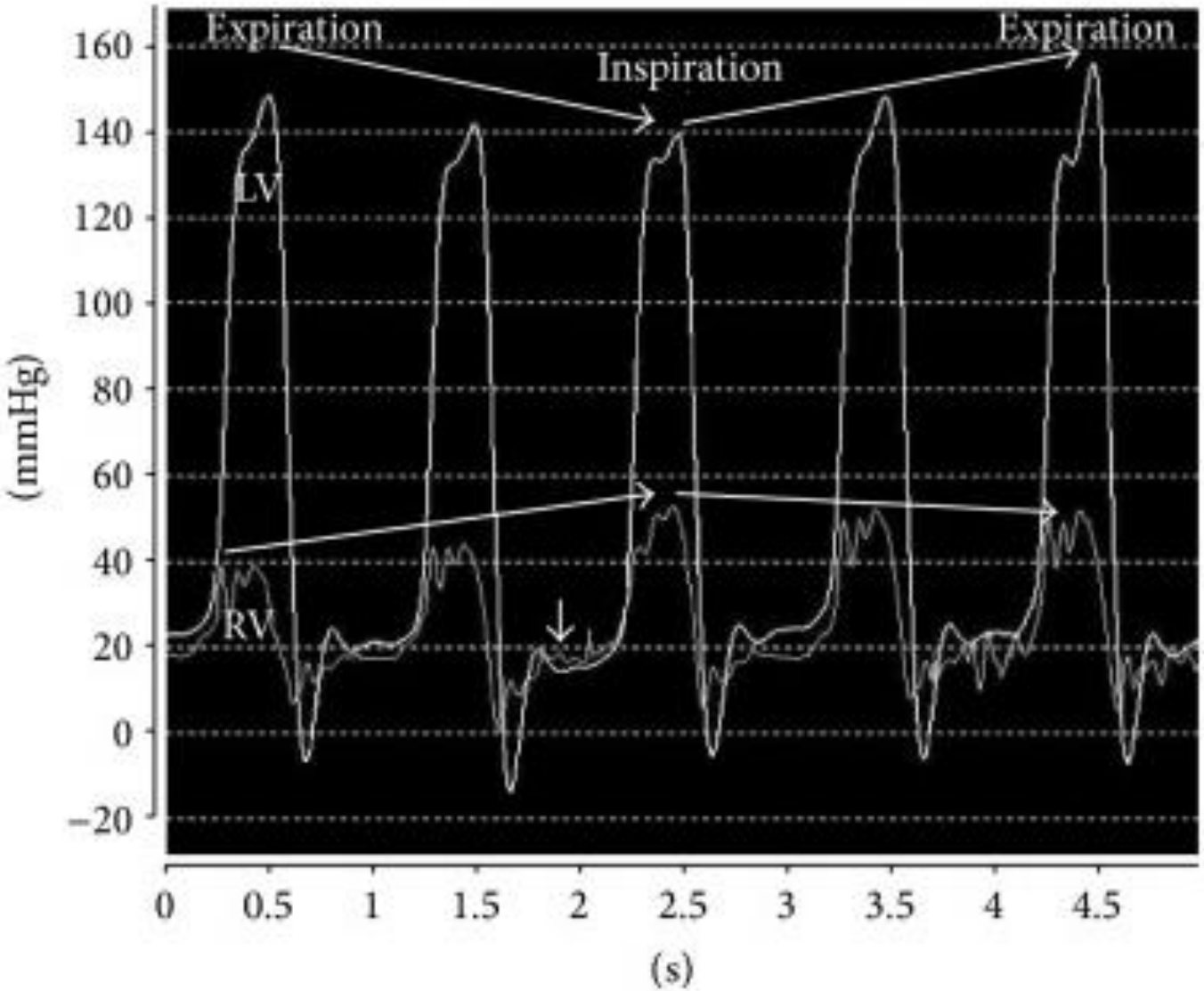
**ANSWER: BOTH HAVE HIGH PRESSURES AND RAPID Y DESCENT, CONSTRICTION ALSO HAS RAPID X DESCENT**

# Constriction or restriction?




Rivinius et al. Case Reports in Transplantation. 2015.

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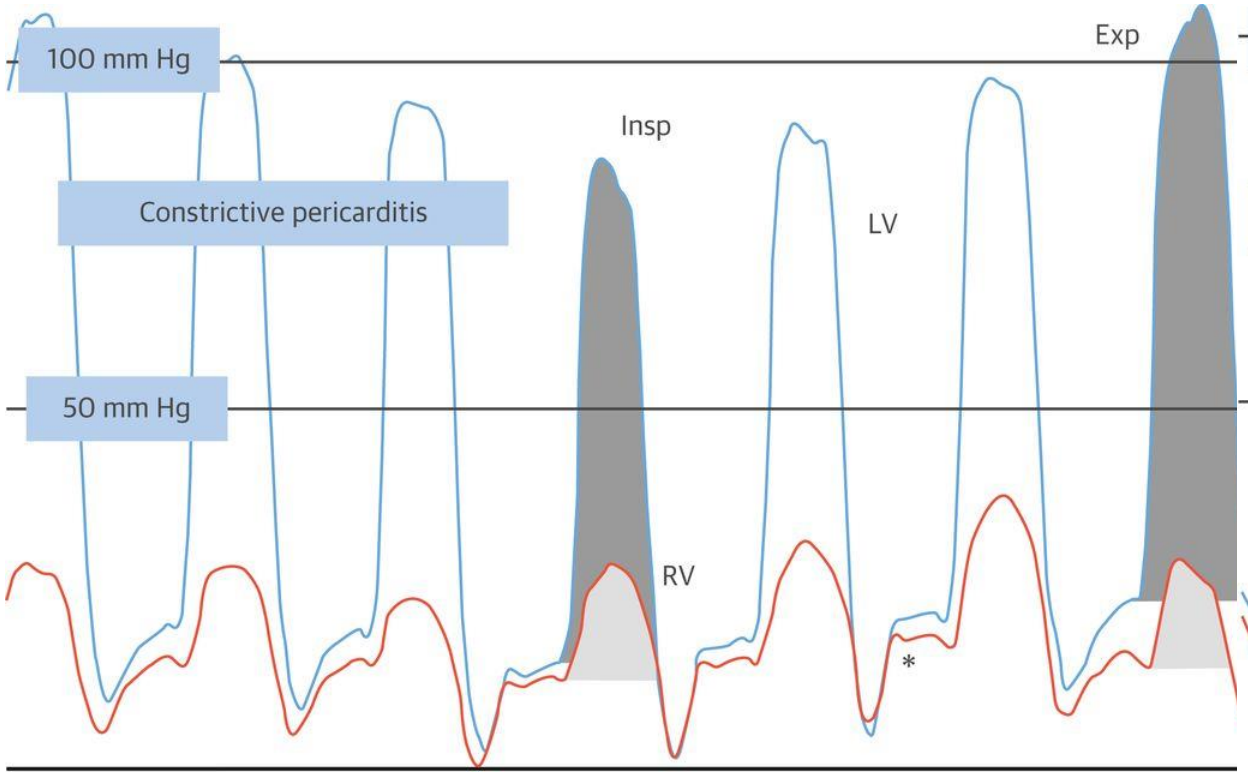
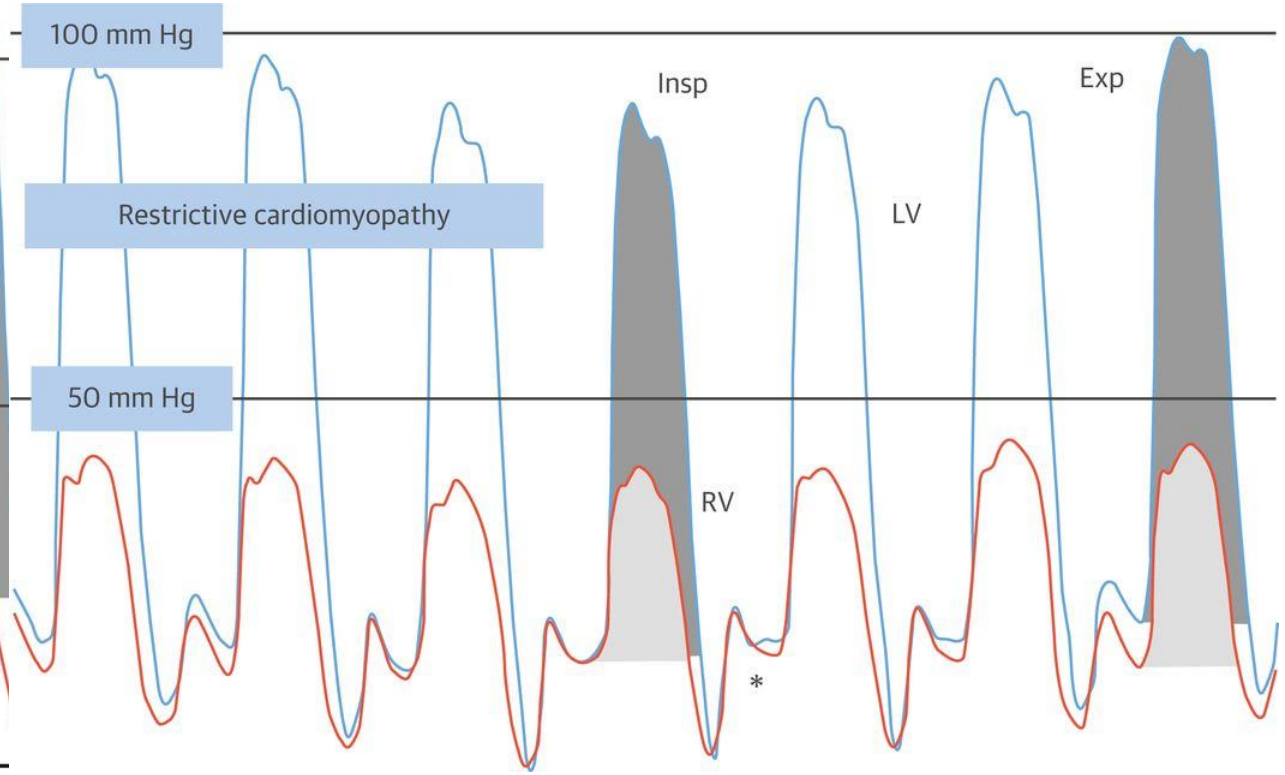
# ANSWER: CONSTRICTION (VENTRICULAR INTERDEPENDENCE)

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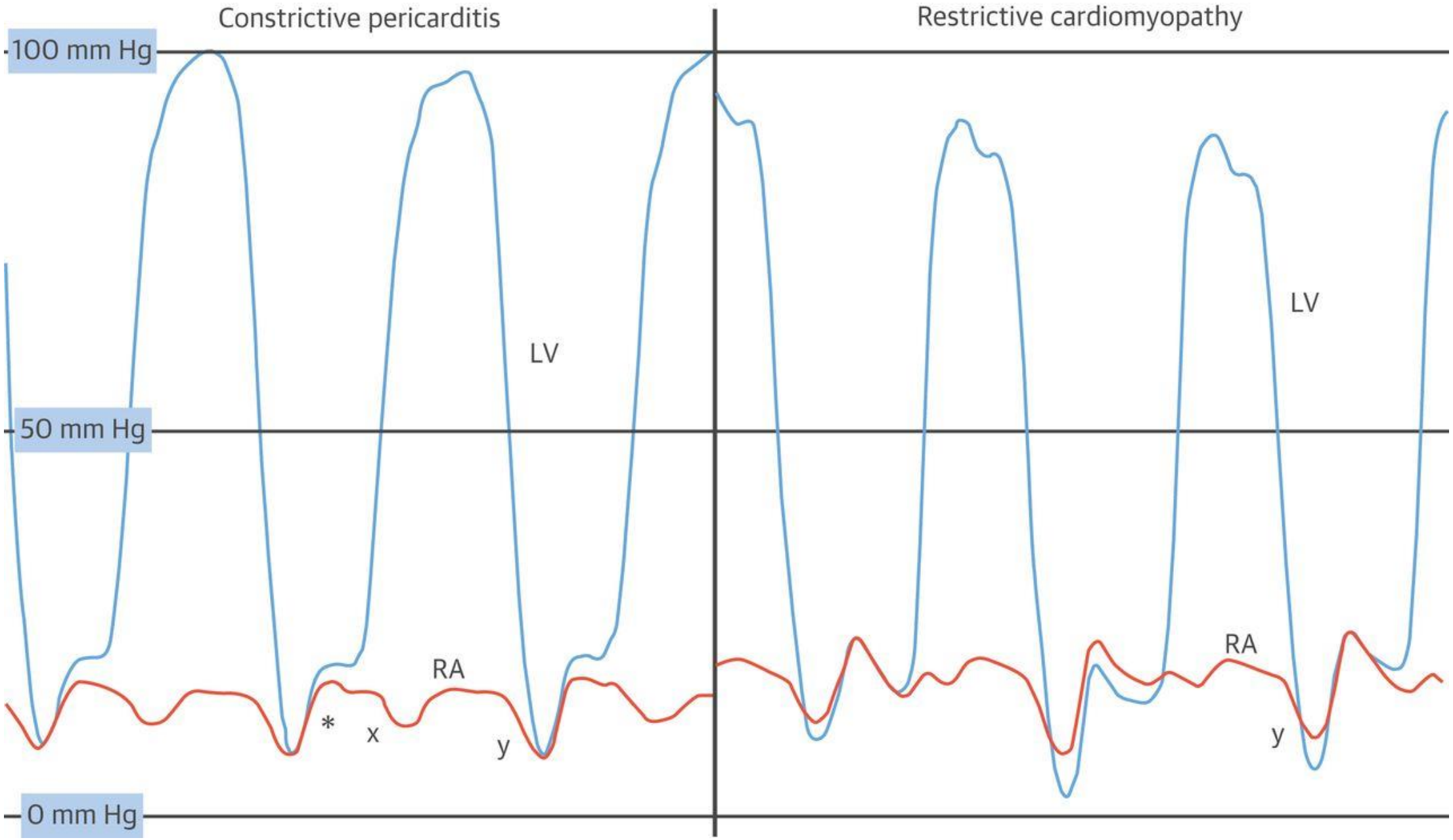
Geske et al. JACC. 2016.




Geske et al. JACC. 2016.

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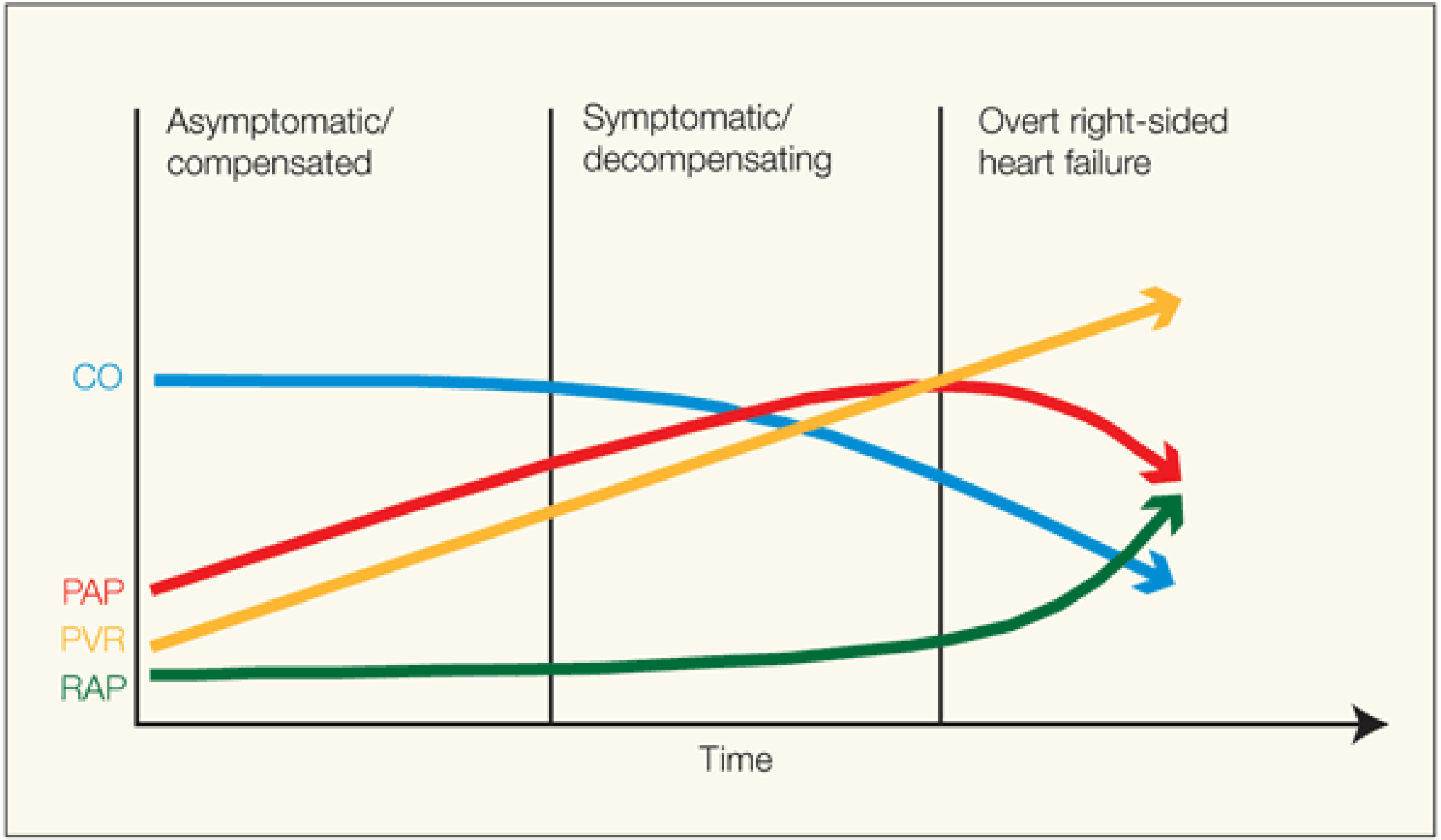
# Summary

| | Constriction | Restriction |
|---|---|---|
| **Main issue** | Pericardial | Myocardial |
| **RA waveform** | ↑x<br>↑y | ↓x<br>↑y |
| **RV filling** | Square root | Square root |
| **Ventricular interdependence** | **Yes** | No |

# Longstanding PAH → good or bad?

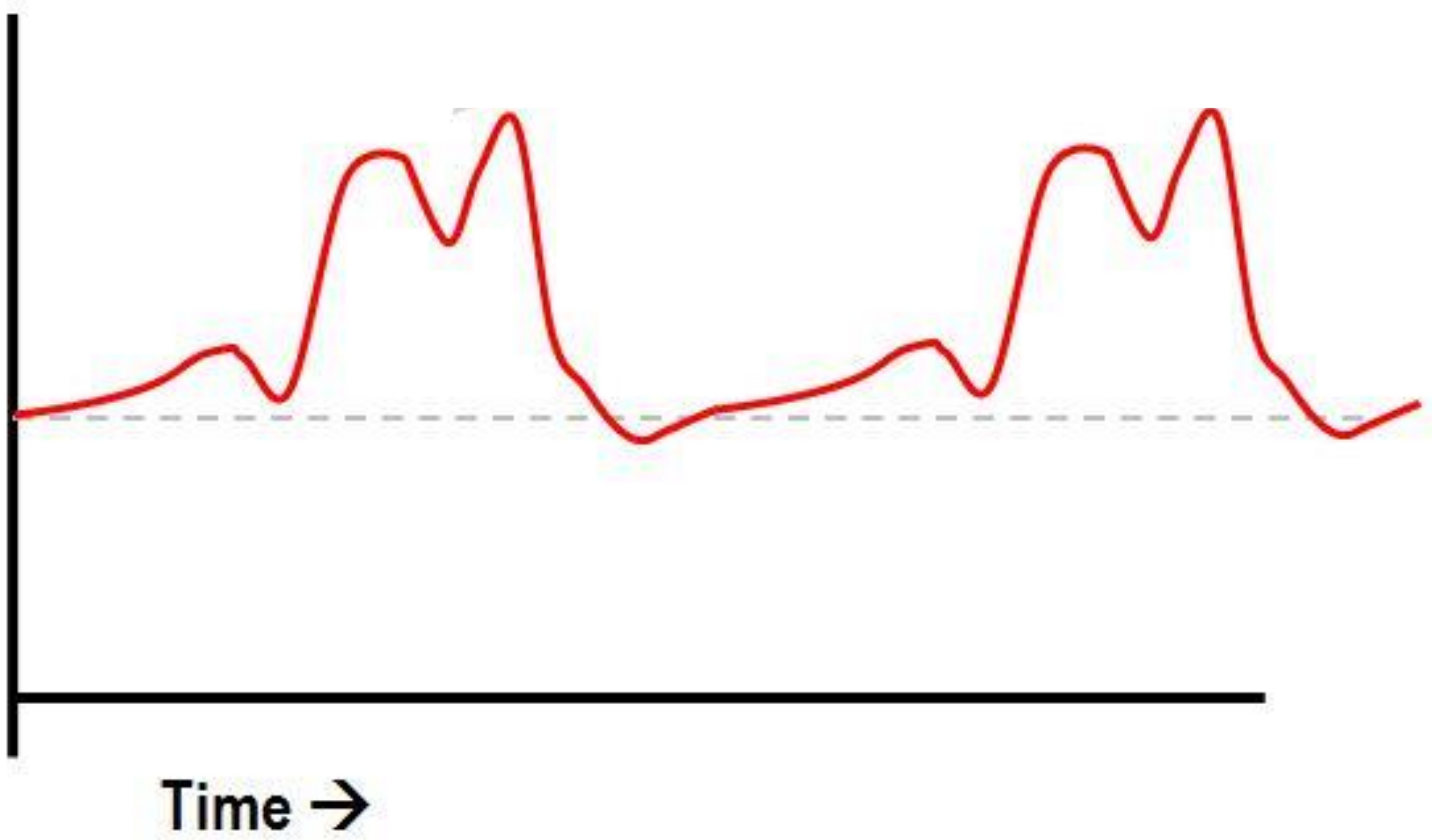
| | |
|---|---|
| RA | 15 mmHg |
| PA | 33/27 (29) mmHg |
| PCW | 9 mmHg |
| CO | 2.5 L/min |

**ANSWER: BAD – DESPITE LOWER PA PRESSURES, POOR MARKERS OF RV FUNCTION (RA/PCW, PAPI) AND LOW CO**




https://www.patientcareonline.com/view/pulmonary-arterial-hypertension-monitoring-patients-response-therapy-part-1

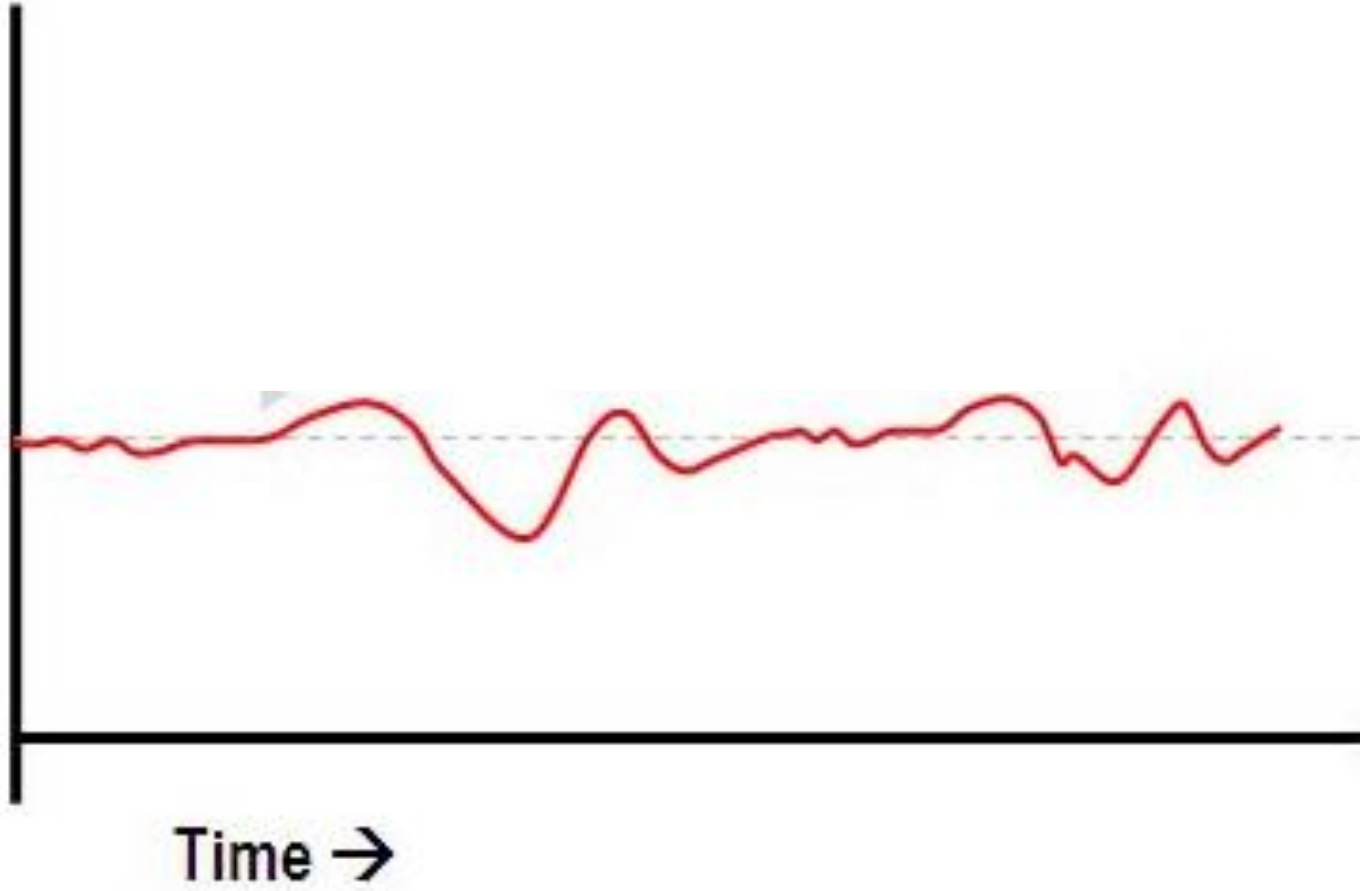
# Cardiac diagnosis?




https://derangedphysiology.com/main/cicm-primary-exam/required-reading/cardiovascular-system/Chapter%20784/abnormal-central-venous-pressure-waveform-patterns

# ANSWER: TRICUSPID REGURGITATION (FUSED C AND V WAVE)

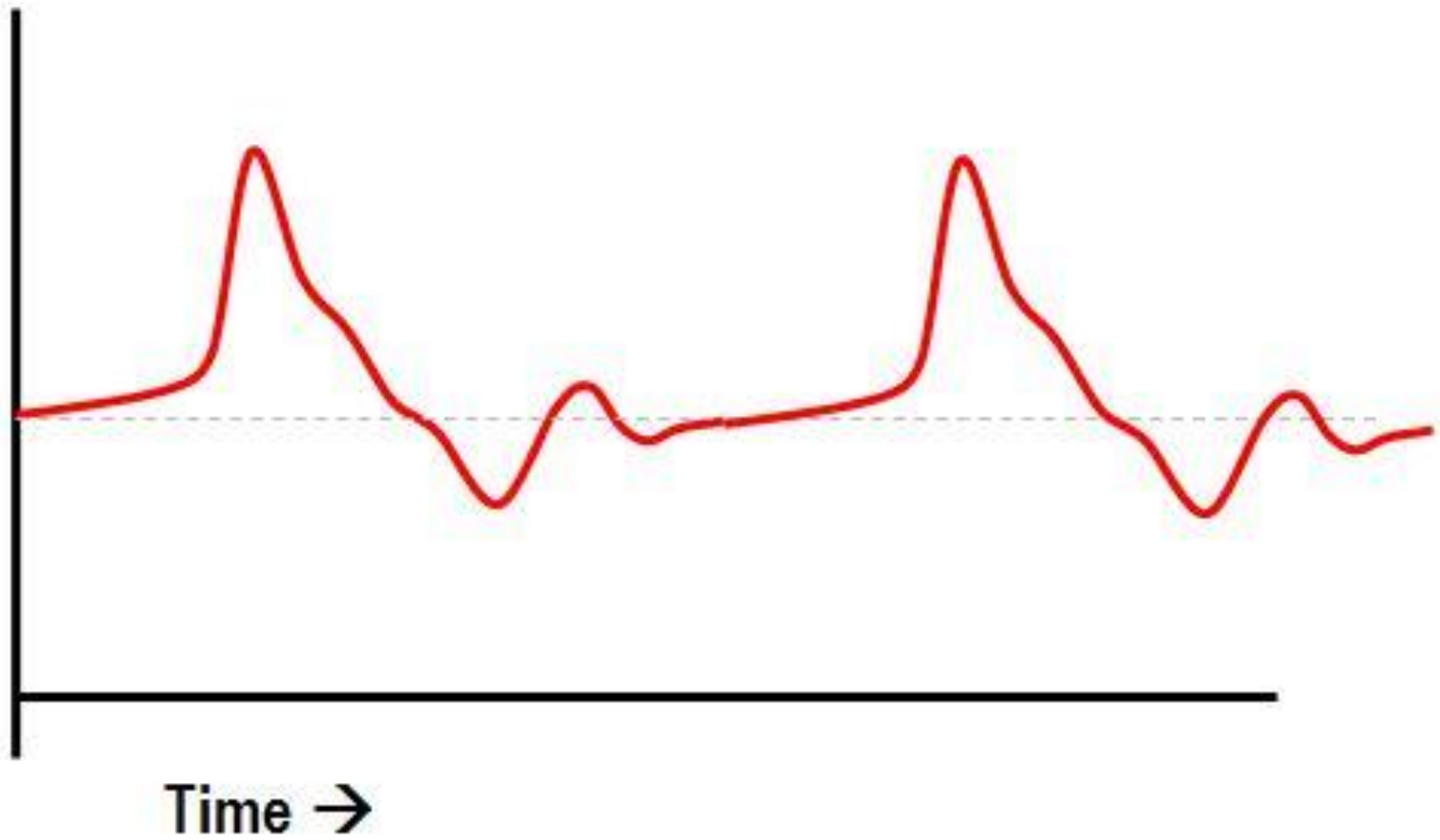
# Cardiac diagnosis?




https://derangedphysiology.com/main/cicm-primary-exam/required-reading/cardiovascular-system/Chapter%20784/abnormal-central-venous-pressure-waveform-patterns

# ANSWER: ATRIAL FIBRILLATION (NO A WAVES)

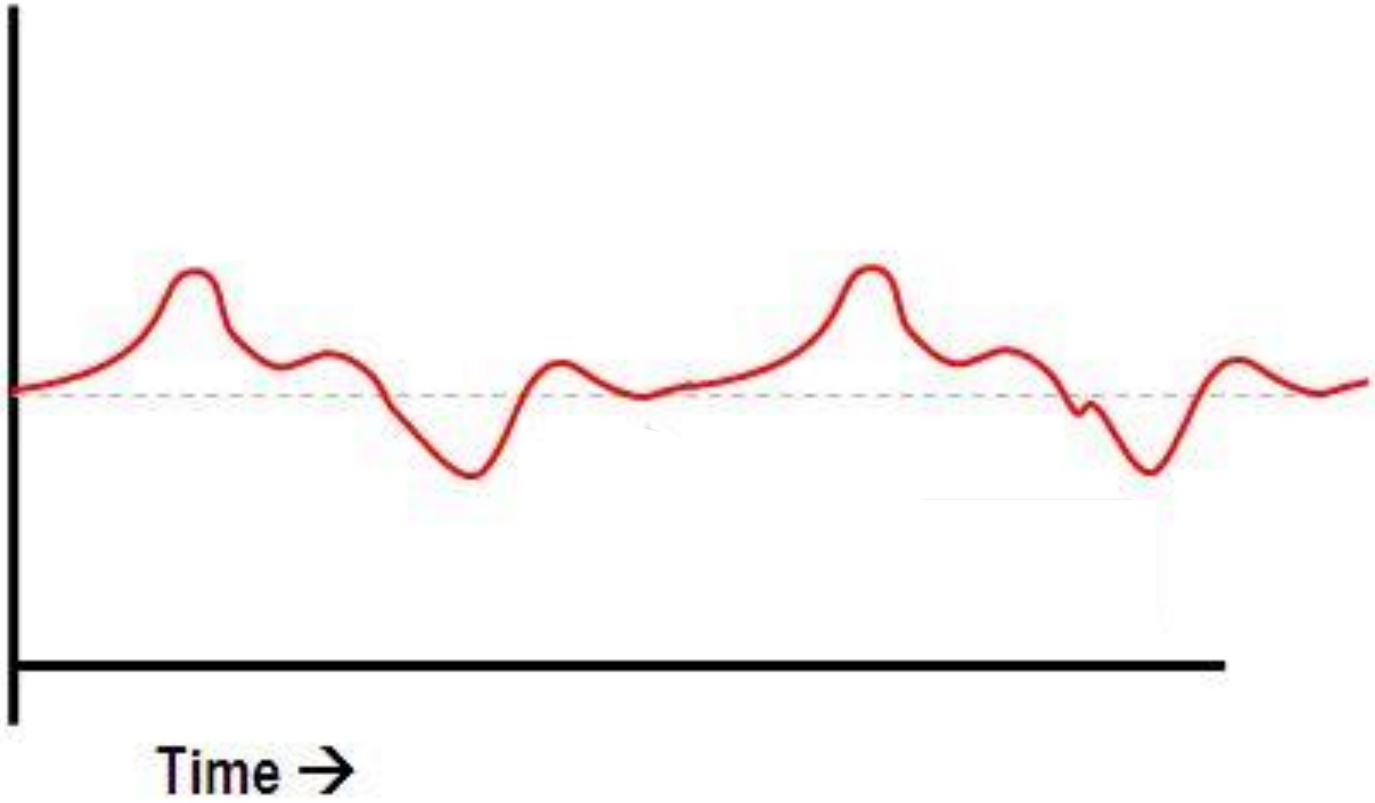
# Cardiac diagnosis?




https://derangedphysiology.com/main/cicm-primary-exam/required-reading/cardiovascular-system/Chapter%20784/abnormal-central-venous-pressure-waveform-patterns

# ANSWER: AV DYSSYNCHRONY (CANNON A WAVES)

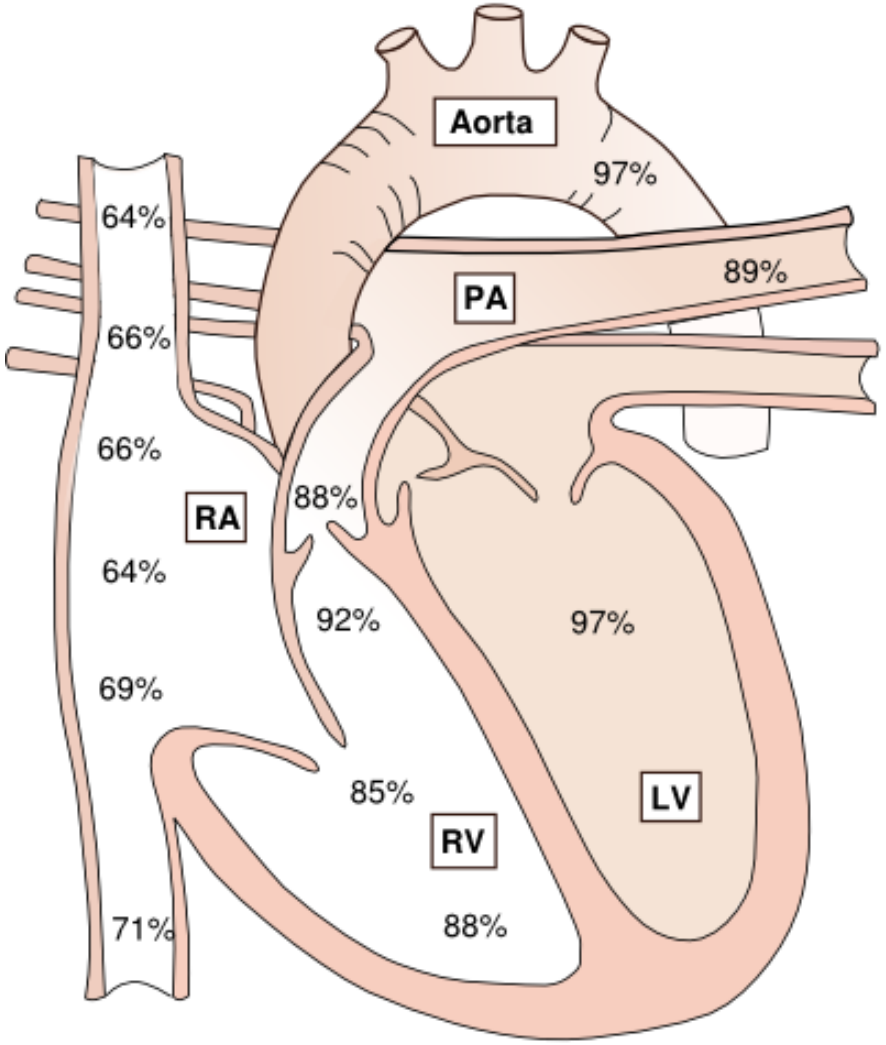
# Cardiac diagnosis?




https://derangedphysiology.com/main/cicm-primary-exam/required-reading/cardiovascular-system/Chapter%20784/abnormal-central-venous-pressure-waveform-patterns

# ANSWER: TRICUSPID STENOSIS (LARGE A WAVE WITH SLOWED Y DESCENT)

# Type of shunt and Qp/Qs?




*Assume MVO2 ~ 65%*

http://www.pcipedia.org/wiki/Hemodynamic_principles:_pressure_measurement,_cardiac_output_and_shunt_detection#Shunt_detection

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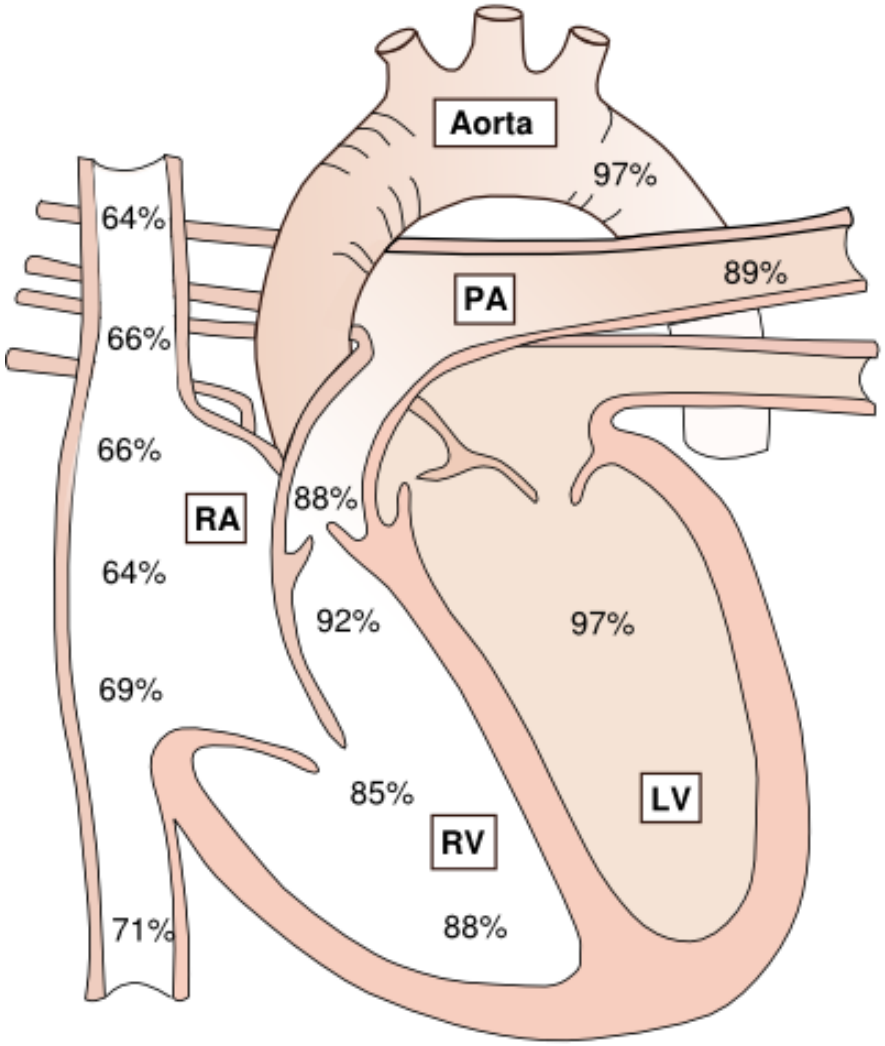


*Assume MVO2 ~ 65%*

**VSD**

Qp/Qs = (Ao – MV) / (PV – PA)

= (97-65) / (97 – 89)

= 32 / 8

**= 4**

http://www.pcipedia.org/wiki/Hemodynamic_principles:_pressure_measurement,_cardiac_output_and_shunt_detection#Shunt_detection

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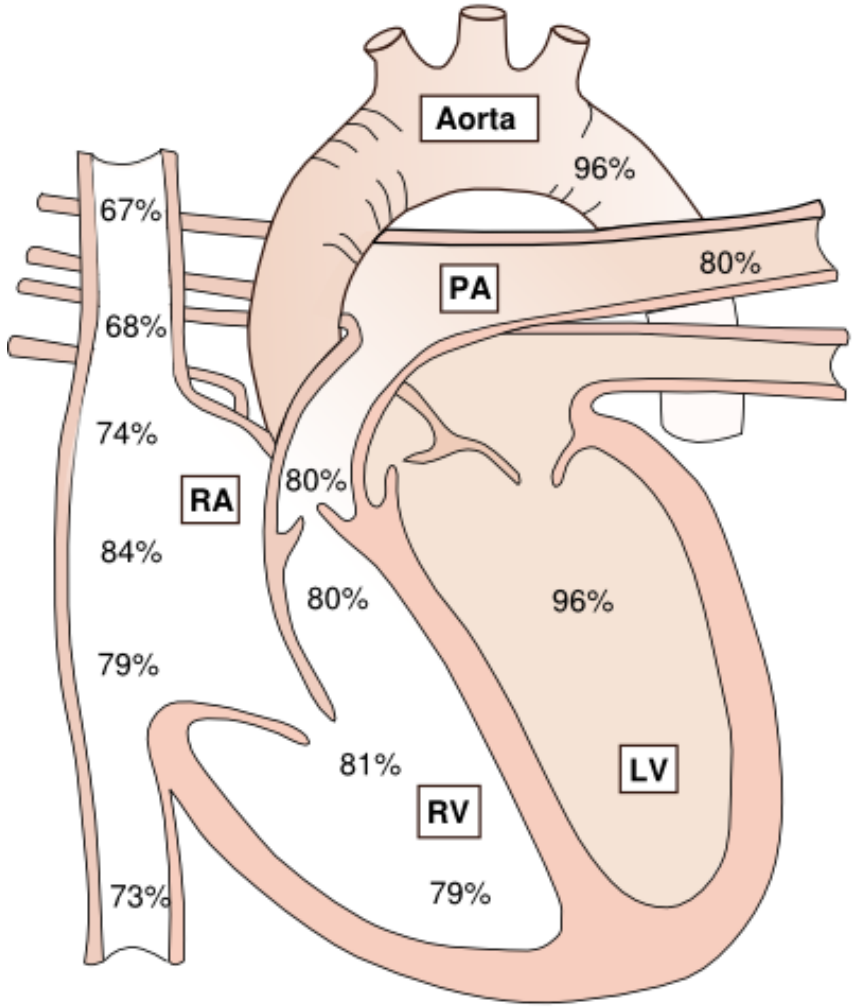
# Type of shunt?




http://www.pcipedia.org/wiki/Hemodynamic_principles:_pressure_measurement,_cardiac_output_and_shunt_detection#Shunt_detection

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# ANSWER: ASD