# Heart-Lung Interaction

Ryota Sato, MD
Division of Critical Care Medicine
Department of Medicine
The Queen's Medical Center

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## No COI to disclose

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# Instruction

- It is imperative to understand Heart-Lung interaction for clinical decision making.
- The aim of this presentation is to help anybody involved in ICU care to understand Heart-Lung interaction under Negative Pressure Ventilation (NPV) and Positive Pressure Ventilation (PPV).

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# Heart-Lung Interaction

PHYSIOLOGICAL STUDIES OF THE EFFECTS OF INTERMITTENT POSITIVE PRESSURE BREATHING ON CARDIAC OUTPUT IN MAN[1, 2]

ANDRE COURNAND, HURLEY L. MOTLEY[3], LARS WERKO[4] AND DICKINSON W. RICHARDS, JR.

*From the Department of Medicine, Columbia University, and the Chest and Medical Services o the Columbia University Division, Bellevue Hospital, New York, New York*

Received for publication August 18, 1947

Dr. Andre Cournand received Nobel Prize in Physiology or Medicine 1956. This group opened the door to the physiologic foundations of modern cardiovascular physiology.

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# RV-Lung Interaction vs. LV-Lung Interaction

- When we talk about Heart-Lung interaction, there are two interactions.
- RV-Lung interaction
- LV-Lung Interaction

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# RV-Lung Interaction

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# Venous System

- Preload = RV end-diastolic wall stress.
- In a normal heart, RV end-diastolic volume varies widely with minimal changes in RV pressure.
- The PG for venous return to the RV is $P_{RA} - P_{MSP}$
- Respiratory cycles can directly affect $P_{RA}$ and, hence, affect this PG.

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# Venous System

- Transmural pressure: PG between RA and surrounding structure (In the absence of tamponade, it is usually $P_{RA}$ and $P_{pl}$ [pleural pressure]).
- $P_{TM} = P_{RA} - P_{pl}$

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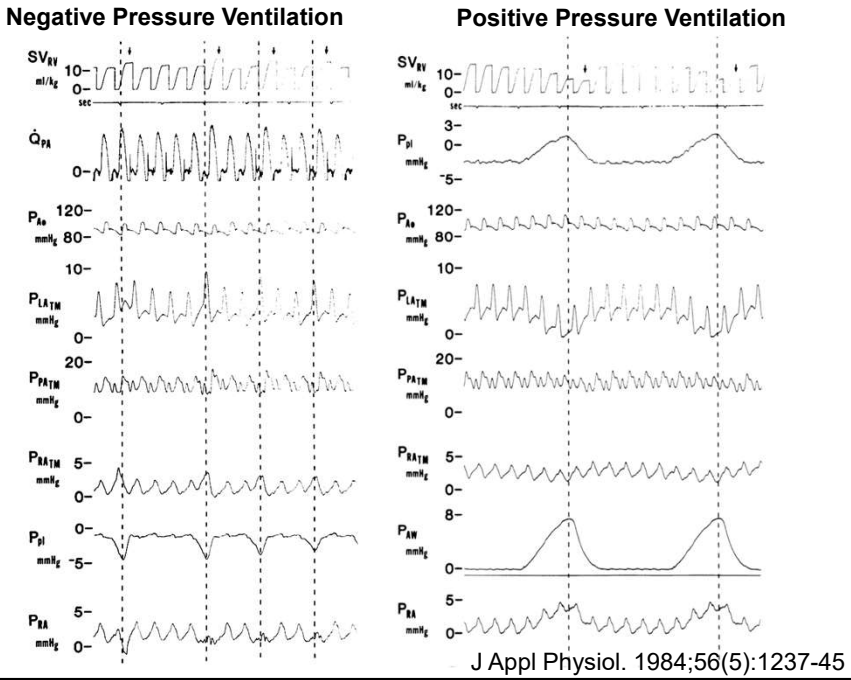


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## Effects on Pulmonary Vascular Resistance

Pulmonary Vascular Resistance can be altered by ventilation via:

- Hypoxic vasoconstriction
- Mechanical vascular compression

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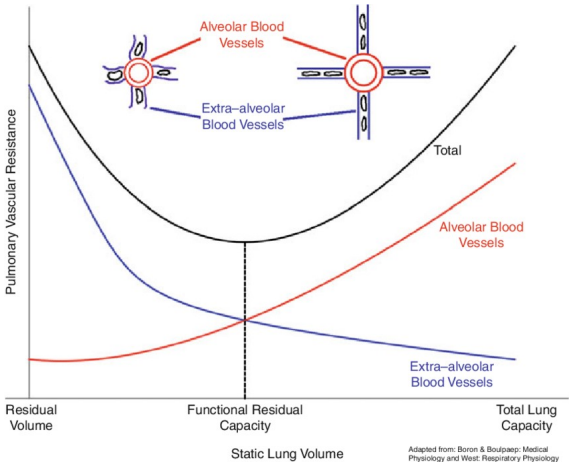
# Pulmonary Venous Pressure




Pediatric and Congenital Cardiology, Cardiac Surgery and Intensive Care 2014;3147-3181

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# Rational Use of PEEP

- Return End-Expiratory Volume back to FRC (Minimal PVR)
- PEEP increases PVR in normal lung
- PEEP decreases PVR in acute lung injury

Canada et al. Crit Care Medicine.1982;10:719-723

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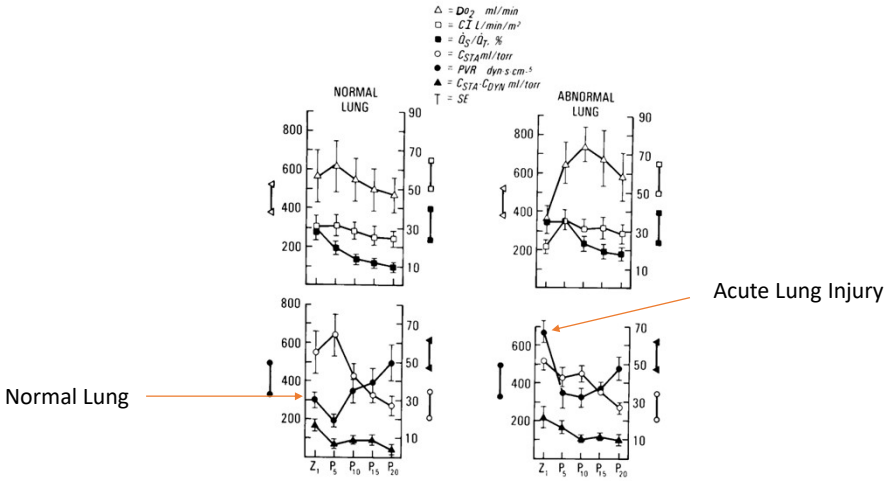
# Effect of PEEP on PVR




Canada et al. Crit Care Medicine.1982;10:719-723

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# Acute Cor Pulmonale during Protective Lung Ventilation

- Historical Review showed Acute Cor Pulmonale decreased from 45% to 25% with Protective Lung Ventilation

Crit Care Med 2001;29:1551-1555

- RV injury/ACP had a higher mortality in ARDS

Crit Care 2021;25:172

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# LV-Lung Interaction

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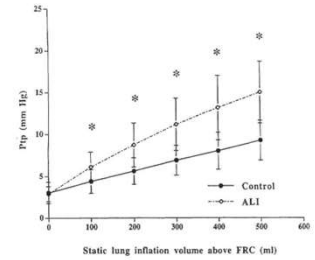
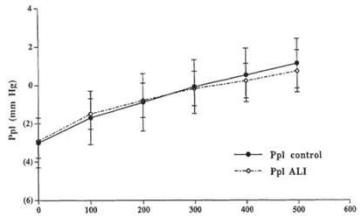
# Hemodynamic Effect of Intrathoracic Pressure




- Transpulm pressure = $P_{alv} - P_{pl}$
- Not airway pressure But increase in Lung Volume is determining Intrathoracic Pressure

CHEST 1995;108(4):1041-8.

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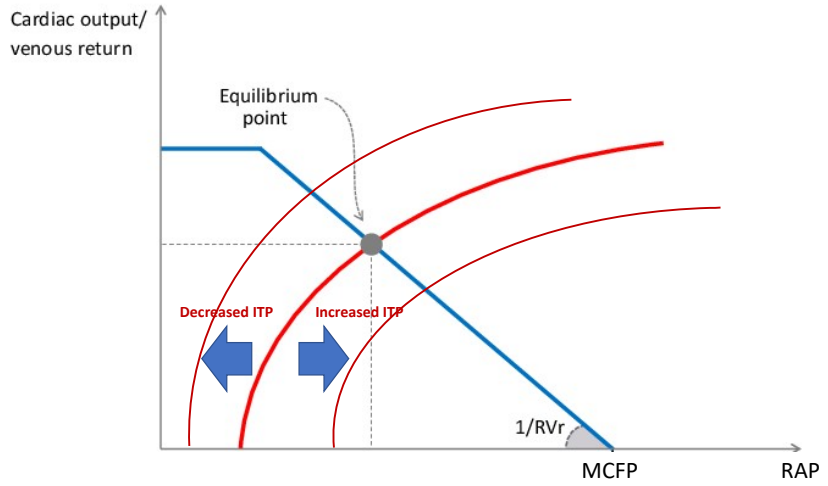
## How ITP affects Frank-Starling Curve?

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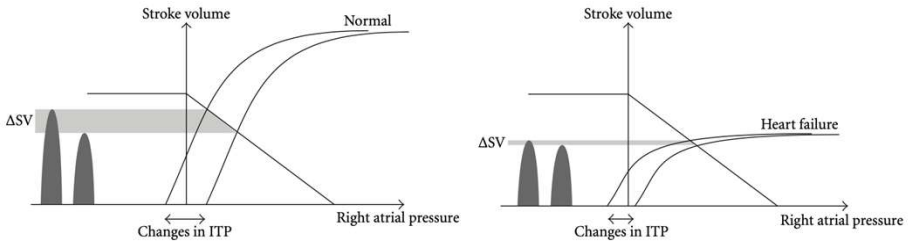
## Increased ITP in LV Failure




Cardiol Res Pract 2012;894:894308

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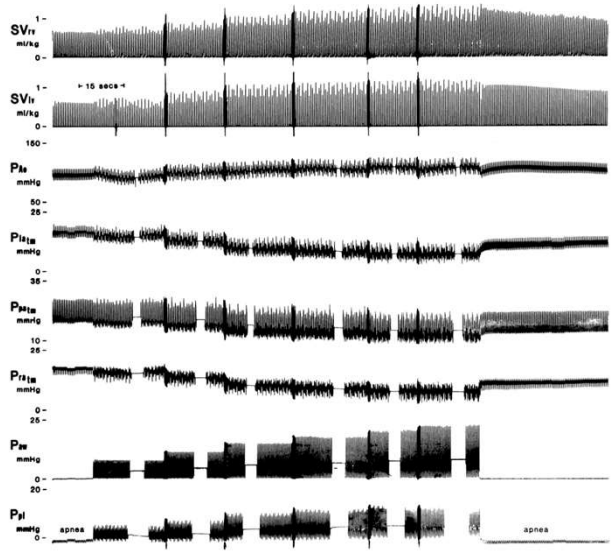
# PPV in LV failure




J Appl Physiol. 1985;58:1189098

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# Effect of ITP on LV afterload

- Increase in ITP = Transmural LV pressure decreases, hence, LV afterload decreases.
- Decrease in ITP = Transmural LV pressure increases, hence, LV afterload increases.

→Increase in ITP -> Decrease in LV afterload
→Decrease in ITP -> Increase in LV afterload

N Engl J Med 1979;301:453-459
J Appl Phyiol. 1983;54:950-955

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# PPV and LV cardiac output

- During PPV with higher PEEP or higher TV, inspiration increases Ppl, decreases LV transmural pressure and LV afterload.
- This leads to increase in LV ejection.
- In normal heart, this effect is limited due to decrease in VR.
- However, when LV systolic function low, ”decrease in LV afterload” >> “decrease in VR”. Therefore, CO increases especially in LV systolic dysfunction

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# Summary of effect of PEEP on CO

- PEEP decreases CO by reduction of Preload

Jardin et al. NEJM 1981;304:387-392

- When PEEP ≤ 5cmH2O, PAWP didn’t change from No PEEP.

Pinsky et al. Am Rev Respir Dis 1991;143:25-31

- When PAWP high, PEEP increased CO

Grace et al. Crit Care Med 1982;10:358-360

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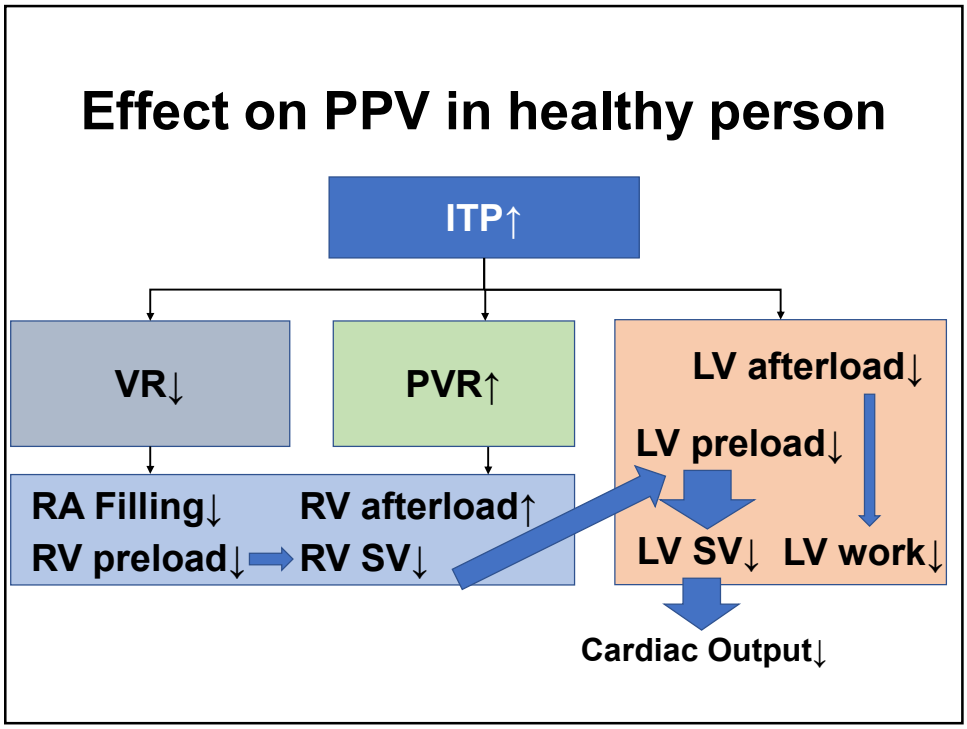
Effect on PPV in healthy person
ITP↑
VR↓
PVR↑
LV afterload↓
LV preload↓
RA Filling↓
RV preload↓
RV afterload↑
RV SV↓
LV SV↓
LV work↓
Cardiac Output↓

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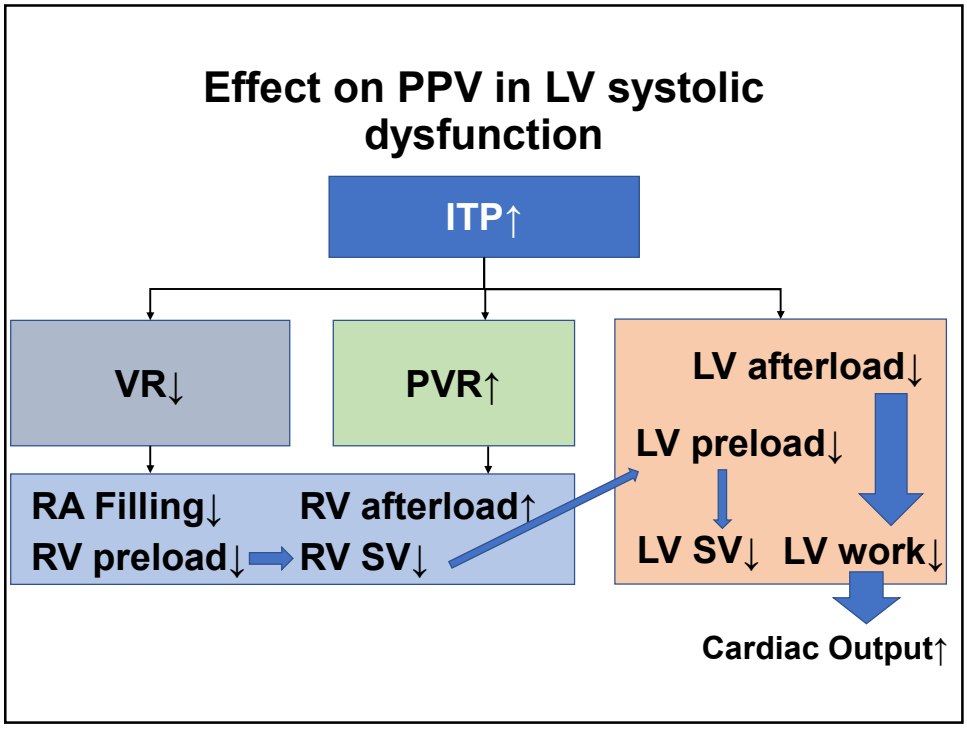
Effect on PPV in LV systolic dysfunction
ITP↑
VR↓
PVR↑
LV afterload↓
LV preload↓
RA Filling↓
RV preload↓
RV afterload↑
RV SV↓
LV SV↓
LV work↓
Cardiac Output↑

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# In Summary

- NPV: Inspiration -> Increase in SV
- PPV: Inspiration -> Decrease in SV

- PEEP: Increase PVR in normal lung
- PEEP: Decrease PVR in ALI
- PEEP: Decrease CO in normal heart
- PEEP: Increase CO in LV failure

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# Thank you

- Questions?

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