Pinsky - Bi-ventricular interdependence (physiology)

On-line lectures ISICEM 2020

Ventricular Interdependence Definitions

- Changes in the filling pressure or volume of one ventricle affects for performance of the other ventricle
- **Diastolic interdependence**: changes in one ventricle's end-diastolic pressure or volume inversely alters the other ventricle's end-diastolic volume
- **Systolic interdependence**: changes in one ventricle's ejection pressure directly alters the other ventricles ejection performance

Usually RV main driver of LV fill , as it has the volume of VR

Usually LV main driver of RV , as it has the energy

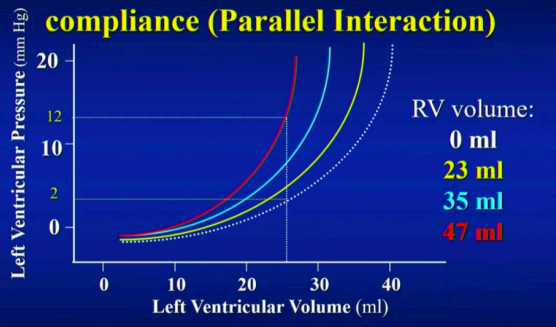
Ventricular Interdependence can be direct (parallel) or indirect (series) Parallel and Series Interactions

- Immediate effects: **Parallel**
  - Both ventricles have the same beat frequency, diastole and systole
  - Share a common intraventricular septum and pericardium
  - Effects on the opposite ventricle occur on the **SAME BEAT**
- Delayed effects: **Series**
  - Changes in RV output must eventually change LV output
  - Changes in LV output **if sustained** must eventually change RV output

Diastolic Ventricular Interdependence

- Absolute bi-ventricular end-diastolic volume is limited by pericardial restraint
- Increases in RV end-diastolic volume decrease LV diastolic compliance, decreasing LV stroke volume on the same beat via the Frank-Starling mechanism.
- Normally seen with forceful inspirations against airway obstruction (bronchospasm, laryngeal spasm)
- Pathologically seen with tamponade, tension pneumothorax and hyperinflation: **Pulsus paradoxus**

Increases in RV volume decrease LV diastolic compliance (Parallel Interaction)

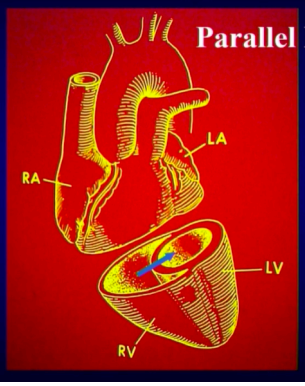


Taylor et al. Am J Physiol 213:706-10, 1967

Diastolic Ventricular Interdependence

- Primarily right to left on a beat-to-beat fashion with increasing RV end-diastolic volume
- But if RV stroke volume changes, after 2-3 beats LV stroke volume also changes by the Frank-Starling Mechanism
- Physiologic basis for Positive-Pressure Ventilation induced Stroke Volume and Pulse Pressure Variation being predictive of volume responsiveness
- Explains why decreasing RV end-diastolic volume in acute cor pulmonale improves LV end-diastolic volume and stroke volume

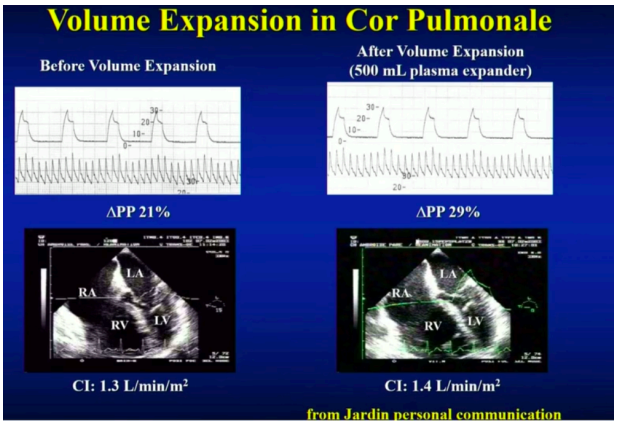
Spontaneous Ventilation Alters LV Filling by Ventricular Interdependence



Systolic Ventricular Interdependence

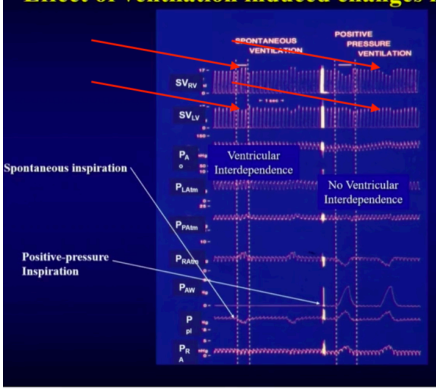
- Both ventricles share a common intraventricular septum
- LV myofibrils from the free wall connect directly to RV free wall myofibrils
- Is systolic ventricular interdependence similar to diastolic ventricular interdependence?

Volume Expansion in Cor Pulmonale



from Jardin personal communication

Effect of ventilation induced changes in RV Input on LV Output



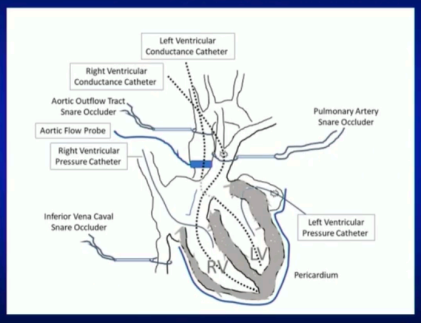
Parallel Interaction
Increases in RV EDV immediately decrease LV EDV
Series Interaction
Decreases in RV EDV indirectly decrease LV EDV over time

Parallel interaction - the diastolic vol change (usually rt ventricle, more compliant) immediately influences other ventricle = interdependene

Series interaction - a delay in the effect. Ex. PPV, SVV - the filling of the LV is impacted after a delay by the VR to the rt V. Not interdependance

Pinsky et al. J Appl Physiol 58:1189-98, 1985

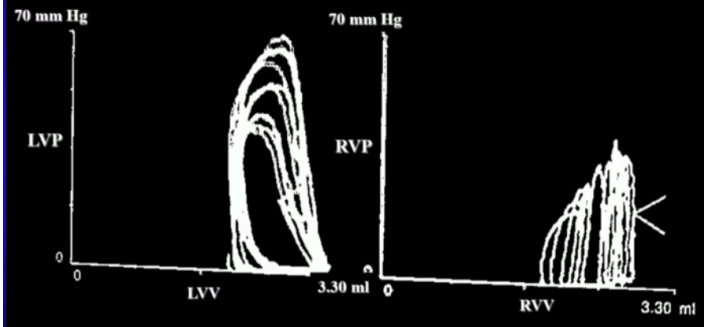
Experimental Models to Assess Biventricular Pressure-Volume Relations



30 years of research

Solda et al. Appl Physiol 73:1770-5, 1992
Pinsky et al. J Crit Care 11:65-76, 1996
Pinsky, Exp Physiol 2020 doi:10.1113/EP088550

Effect of Partial Pulmonary Artery Occlusion On LV and RV Pressure-Volume Loops



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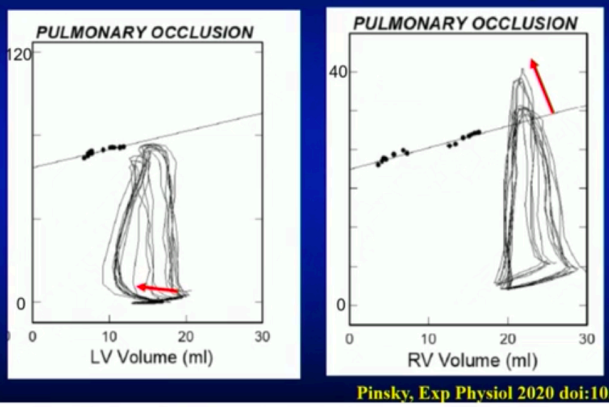

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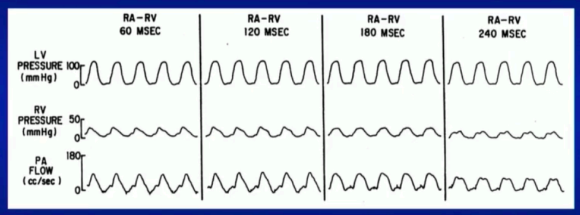
70% of RV Developed Pressure Comes from LV Contraction



63.5 LV vs. 36.5% RV contribution to RV developed pressure

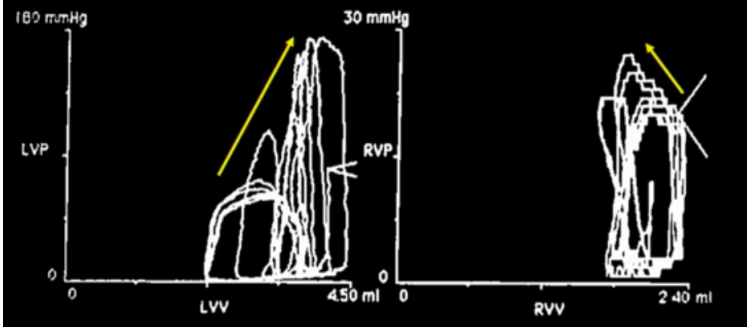
Damiano et al. Am J Physiol 261:1514-24, 1991

Sudden increases in PA pressure

- Impede RV ejection
- Over 2-3 beats decreases LV end-diastolic volume

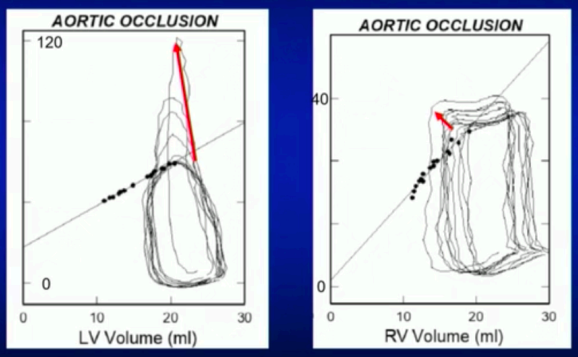
Series Interaction

Effect of Partial Aortic Occlusion On LV and RV Pressure-Volume Loops



Solda et al. Appl Physiol 73:1770-5, 1992

Effect of Partial Aortic Occlusion On LV and RV Pressure-Volume Loops



Series Interaction

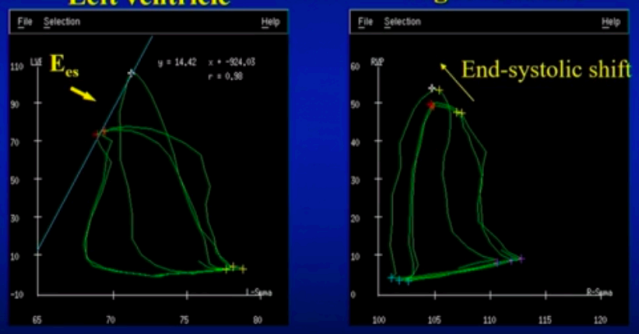
Pinsky, Exp Physiol 2020 doi:10.1113/EP088550

Partial Aortic Occlusion

Closed Pericardium

Left ventricle

Right ventricle



Pinsky et al. J Crit Care 11: 65-76, 1996

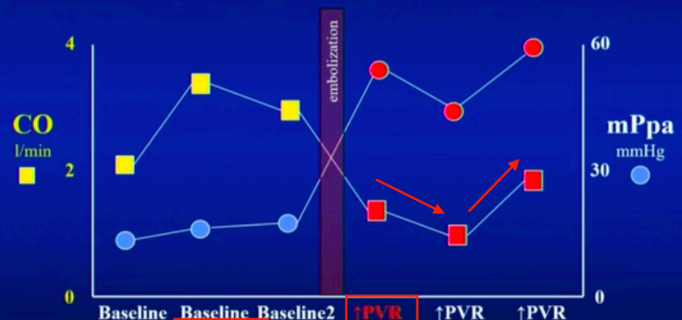
Clinical Relevance: Acute Pulmonary Hypertension

Ex. PE

- Restore RV coronary perfusion pressure
  - Keep MAP>MPAP
- Fluids may or may not help. Overdistention is death
- Increased inotropy can help though systolic interdependence
- Reverse pulmonary hypertension
  - tPA, heperan, iNO
  - Permissive hypercapnia, iNO, PGI, PGE

Inotropes will increase LV systolic function which will increase RV function

Volume Expansion v. Norepinephrine to Treat Low CO during Acute Increases in RV Afterload



Ghignone et al. Anesthesiology 60:132-5, 1984

Ventricular Interdependence

- Diastolic ventricular interdependence
  - Primarily right to left
  - Both parallel and series effects
  - Allows PPV and SVV during positive pressure breathing to predict volume responsiveness
- Systolic ventricular interdependence
  - Primarily left to right
  - Explains RV failure during LVAD insertion
  - Explains norepinephrine benefit for acute cor pulmonale