CARDIAC PERFORMANCE

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MEASUREMENTS OF CARDIAC PERFORMANCE

• CARDIAC OUTPUT (CO)
  • The volume of blood pumped out by one ventricle in one minute (= 5000 mL/ min)
  • CO = SV x HEART RATE

• STROKE VOLUME (SV)
  • SV = EDV - ESV (120 ml - 50 ml)
  • The volume of blood pumped out by one ventricle in one heart beat (= 70 mL /beat)
  • The most important determinant of Arterial Pulse Pressure (e.g. strong vs weak pulse)

• STROKE WORK (SW)
  • SW = SV x ARTERIAL PRESSURE
  – Oxygen consumption by the heart α SW
  – SW for L Ventricle > for R ventricle

DETERMINANTS OF CARDIAC PERFORMANCE

• PRELOAD

• AFTERLOAD

• CONTRACTILITY

• HEART RATE
PRELOAD : DEFINITIONS

• Loading condition on the heart at the end of diastole

• Stretch of myocardial muscle before contraction

PRELOAD - Measured by:

• Ventricular end diastolic volume (EDV)

• Ventricular end diastolic pressure

• Right atrial pressure
  – estimated by the Central Venous Pressure (CVP)

• Left atrial pressure
  – estimated by the pulmonary artery wedge pressure (using a catheter inserted into a small pulmonary vessel)
**PRELOAD vs CO**

- **↑ Preload → ↑ EDV → ↑ SV → ↑ CO**
  (within limits)
  - **Cause**
    - ↑ Preload ←
      - ↑ Venous Return
      - ↑ Aortic Resistance
  - **Significance**
    - CO adjusts automatically to Venous Return

Mechanism of Frank-Starling law:

- overlap of actin & myosin
- length-induced - sensitivity of the myofilaments to Ca²⁺
In Heart Failure, there is decreased Cardiac Performance (compared to a normal heart) for the same degree of muscle fibre stretch.

• Ionotropic drugs increase Cardiac Performance in normal or failing heart.

DETERMINANTS OF CARDIAC PERFORMANCE

• PRELOAD

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AFTERLOAD: DEFINITIONS

• Circumferential ventricular wall stress during ejection
• The amount of force that must be generated by the myocardium in order to eject blood into the arteries
• The load against which the ventricle must contract when it ejects blood into the arteries

DETERMINANTS OF AFTERLOAD

• Wall stress \( (\sigma) = \)
  • Force / cross-sectional area
  • \( PR/2W \) (Law of Laplace)
    \( P = \) intraventricular pressure
    \( R = \) radius of the heart chamber
    \( W = \) thickness of heart wall

NB: \( PR/2W \) for sphere
    \( PR/W \) for cylinder
DETERMINANTS OF AFTERLOAD

\[ \sigma = \frac{PR}{2W} \]

- ↑ Afterload ←
  - ↑ arterial resistance/pressure (e.g. in hypertension)
  - ↑ radius of ventricle chamber (e.g. in heart failure)
  - ↓ thickness of heart wall
    - although hypertrophy increases work load on the heart by increasing wall stiffness (i.e. decreasing compliance of the heart)

AFTERLOAD vs CO

↑ AFTERLOAD → ↓ CO

↑ Afterload → Myocardial hypertrophy
• Cardiac Performance increases with increasing Preload

• Cardiac Performance decreases with increasing Afterload

In Practice:

• When MAP < about 150 mmHg
  ↑ AFTERLOAD → No Change in CO
    • ↑ MAP →
      ↑ EDV →
      ↑ σ → ↑ Intraventricular Pressure to overcome arterial pressure

□ ↑ Afterload → Myocardial hypertrophy
AFTERLOAD vs CO

In Practice:

• *When MAP > about 150 mmHg*
  ↑ AFTERLOAD → ↑ ESV → ↓ SV → ↓ CO

• The ↑ σ is not sufficient to overcome the very high MAP

To be Continued