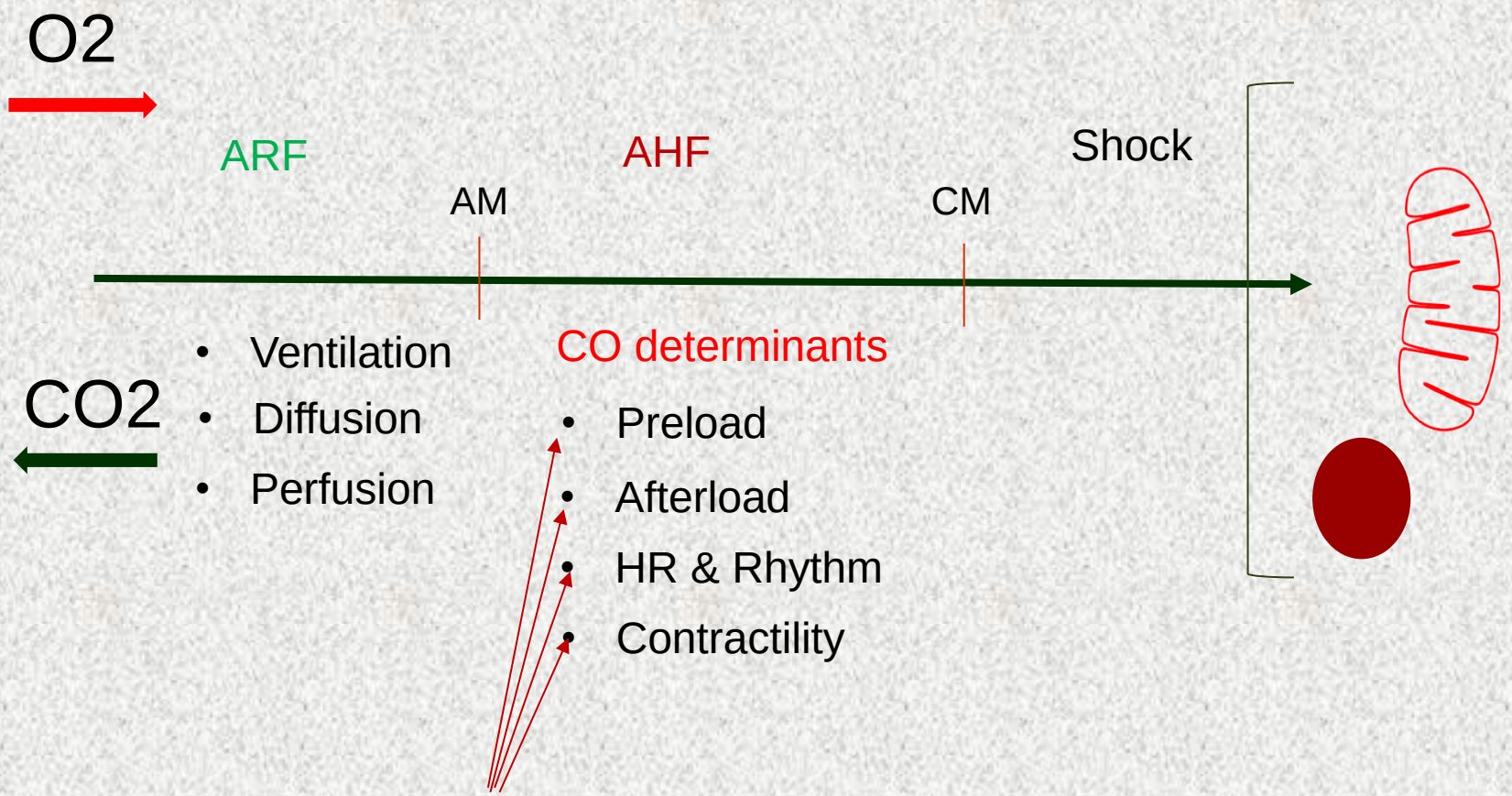
# Acute Heart Failure

Victor Iapascurta, PhD

# Oxygen Cascade:

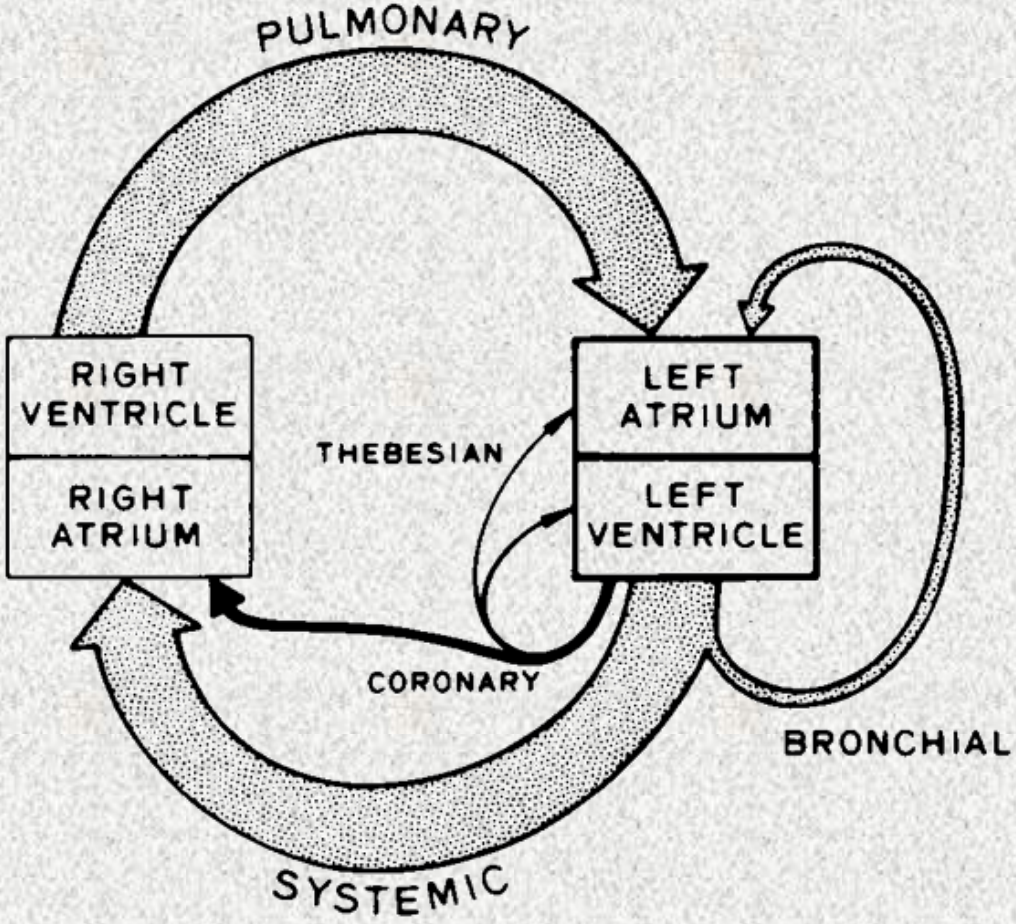
[FiO2] = 0.21 (21%)




$$DO_2 = CO * 1.34 * Hgb * SaO_2$$

# Acute Cardio-Vascular Failure

## Hemodynamics Physiology




- 9% pulmonary vessels
- 7% heart
- 84 % systemic vessels

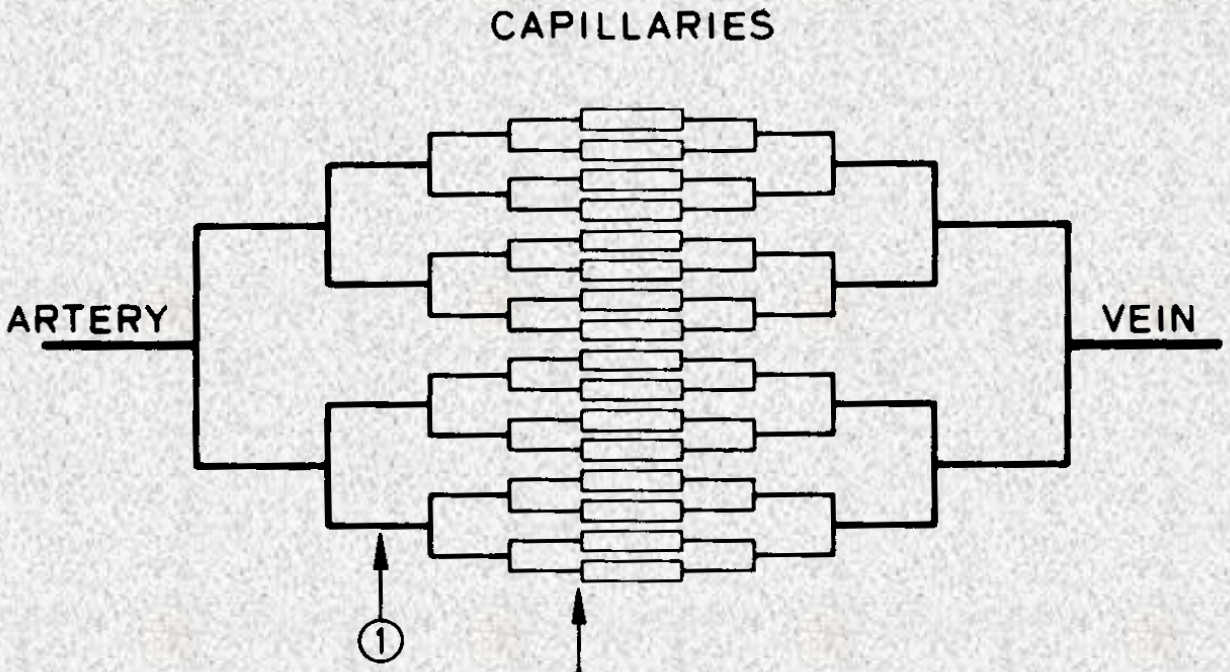
**Major anatomic pathways of blood flow**

## Hemodynamics Physiology

- 84% - systemic vessels
  - 64% - veins
  - 13% - arteries
  - 7% - arterioles & capillaries
- 7% - heart
- 9% - pulmonary vessels

# Acute Cardio-Vascular Failure

## Hemodynamics Physiology



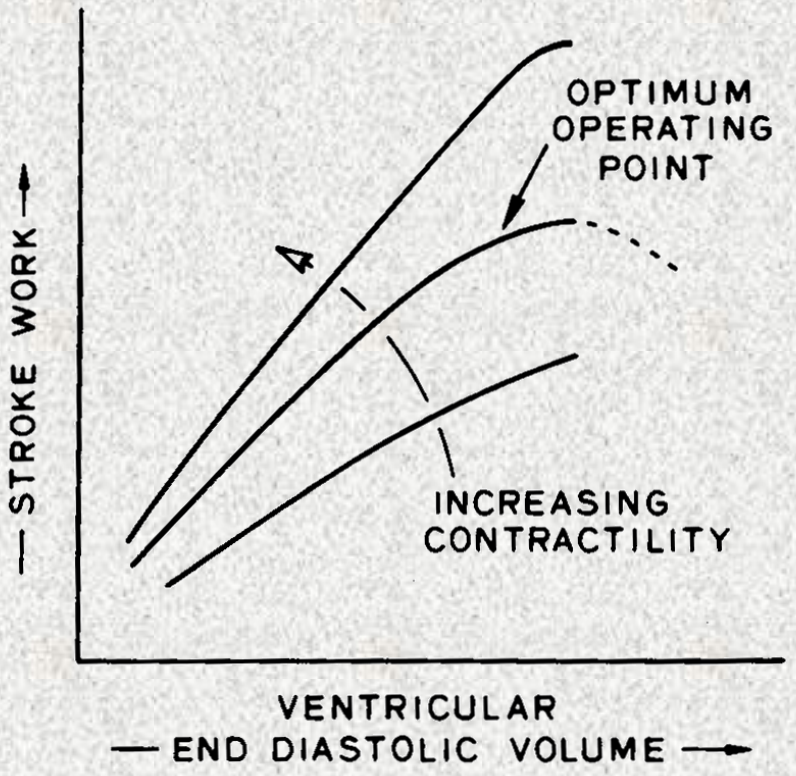

1 - Ganglionic or systemic level

2 - Local level (microcirculation)

Schematic Diagram of the Vascular System

# Acute Cardio-Vascular Failure

## Hemodynamics Physiology

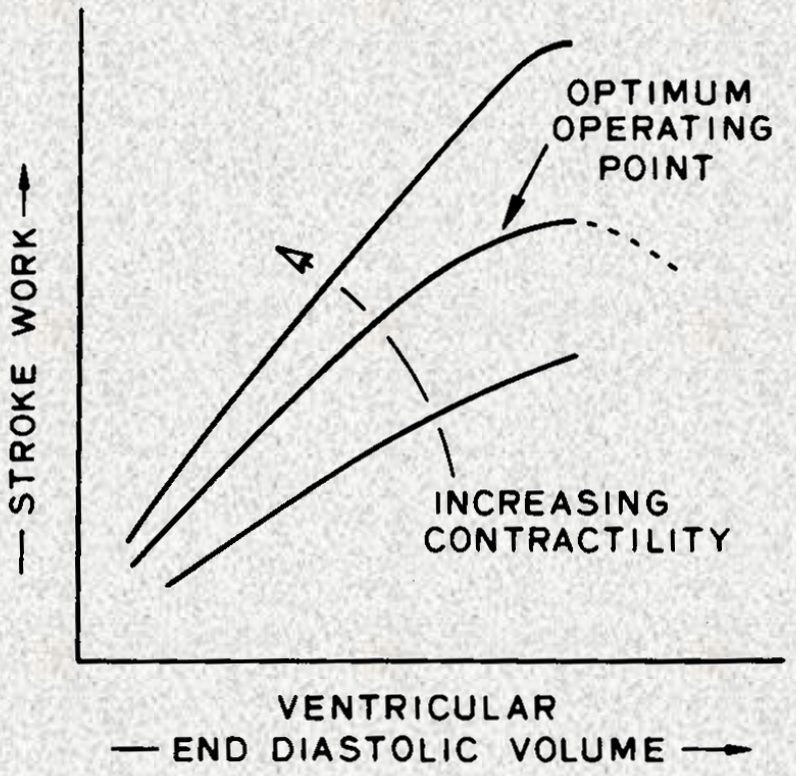



The heart as a pump

Starling's Law

## Hemodynamics Physiology

### The heart as a pump



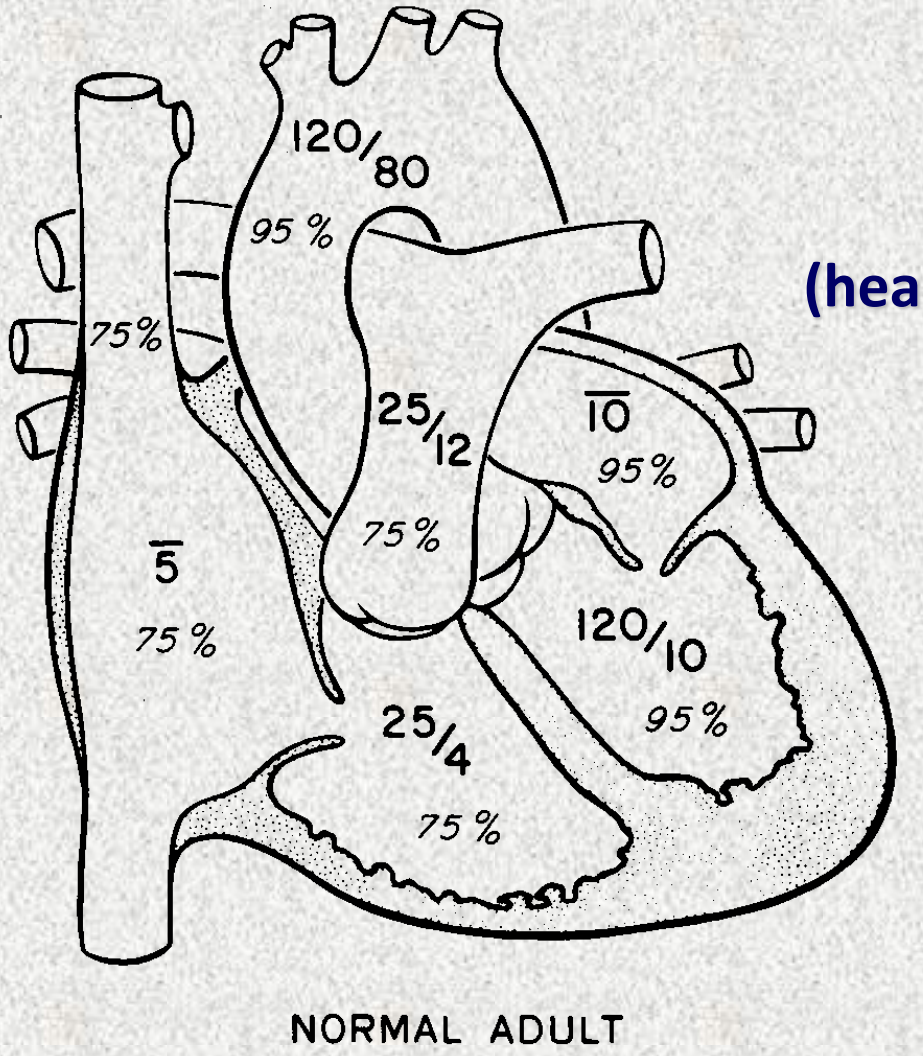

Starling's Law

**A summary of Starling's Law**

- **Original definition**
  **Within physiological limits, increasing**
  **end diastolic volume increases stroke work**
- **Working definition**

**Increasing end-diastolic pressure (preload) increases stroke work to a maximum value**

## Hemodynamics Physiology

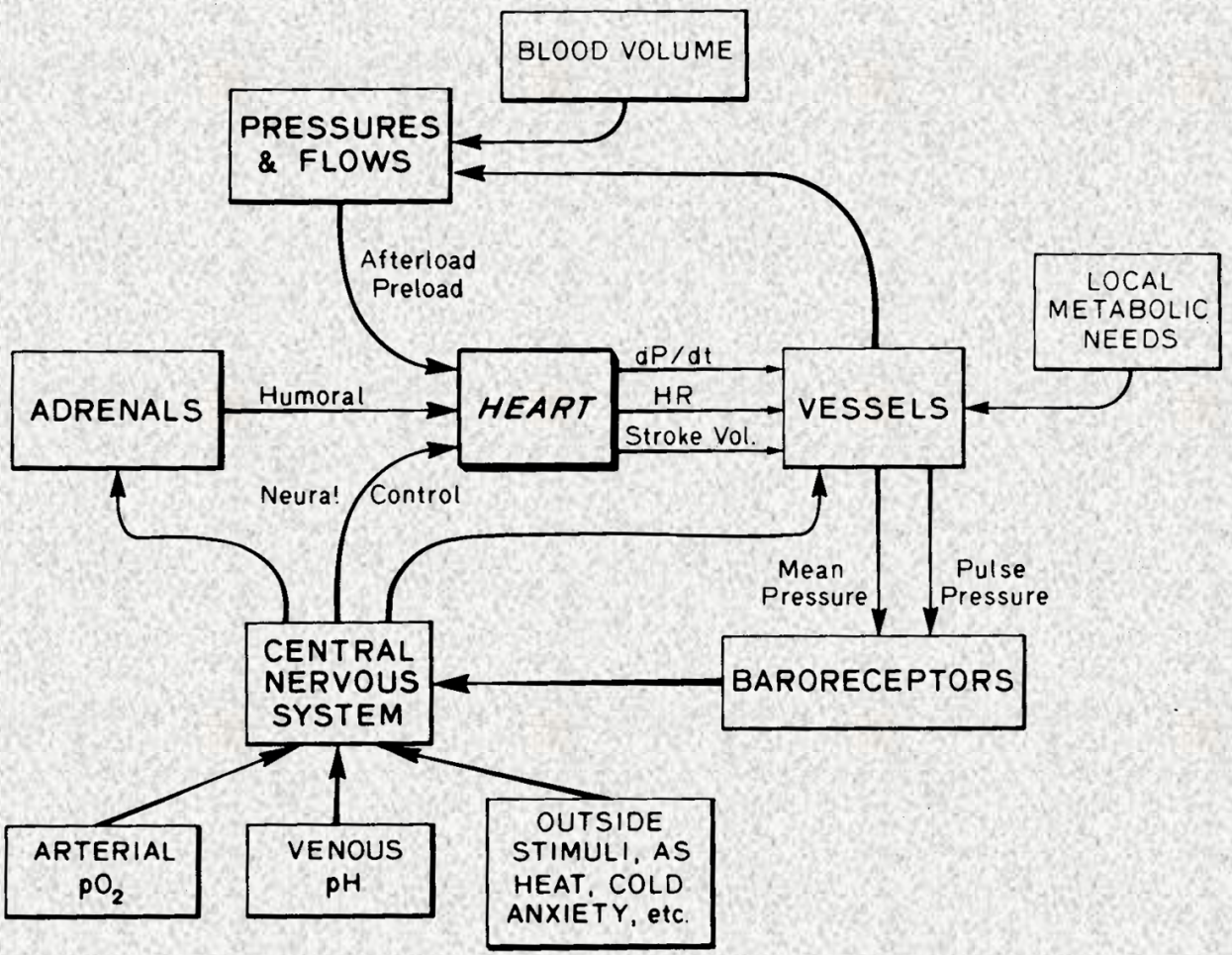



**Pressure and Oxygen Saturation Values**

**(heart and Great Vessels)**

# Acute Cardio-Vascular Failure

## Hemodynamics Physiology




Heart – Systemic Relationships

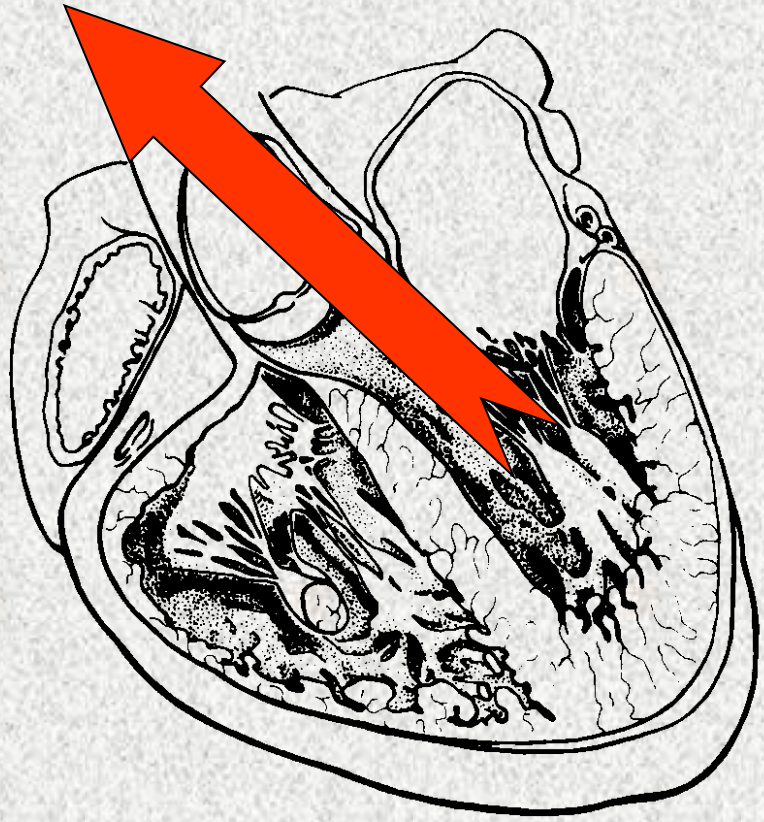
# "Cardiac Output"

# Approach to ICU patients

What "Cardiac Output" is ?

# Acute Cardio-Vascular Failure

## "Cardiac Output" Approach to ICU patients



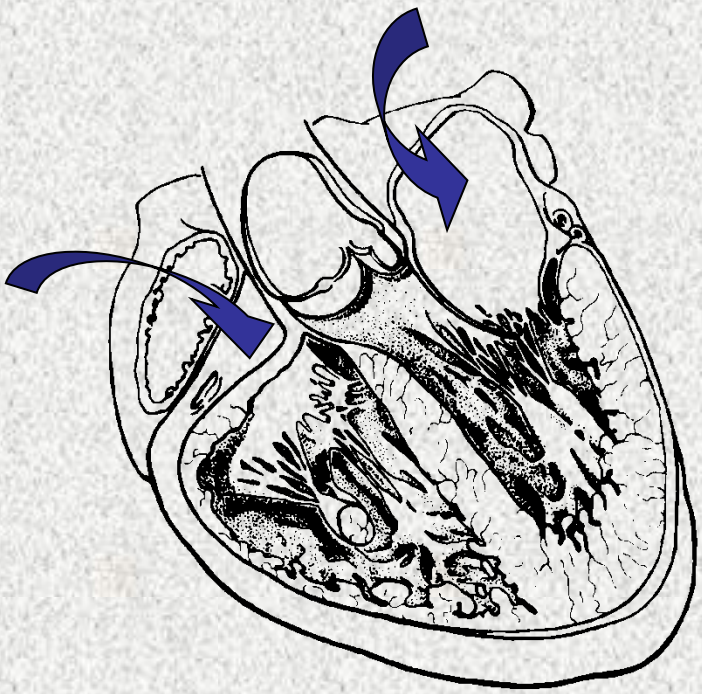
Cardiac Output is the volume of blood pumped /ejected by heart during one minute ( or Stroke Volume x Heart Rate)

## "Cardiac Output" Approach to ICU patients

# Determinants of Cardiac Output (CO)

1. Preload
2. Afterload
3. Myocardial Contractility
4. Heart Rate & Rhythm
5. Compliance

"Cardiac Output" Approach to ICU patients



# Preload

Adequate blood return to the heart is crucial for the cardiac output

# Acute Cardio-Vascular Failure

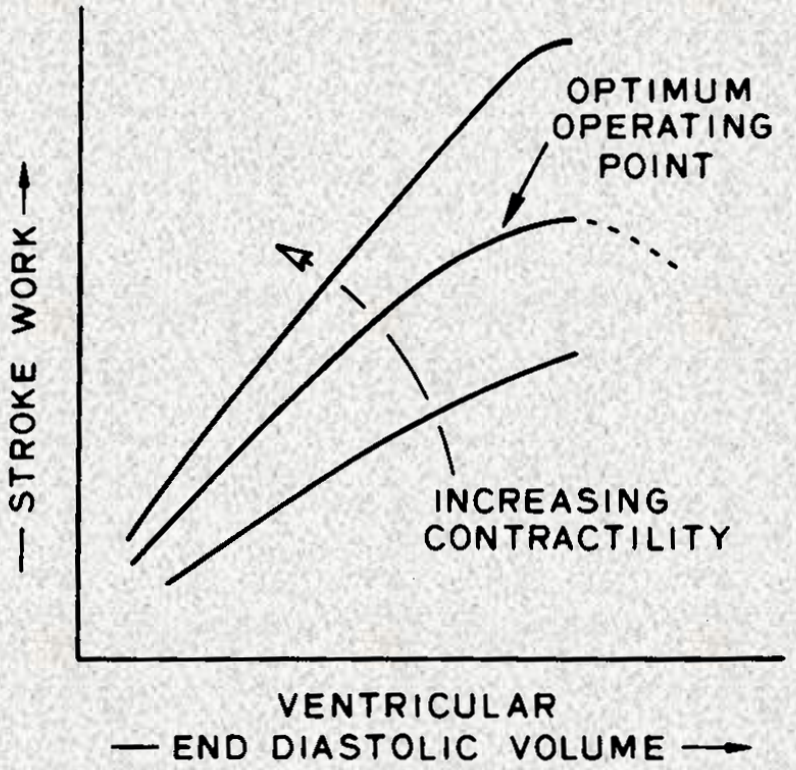
"Cardiac Output" Approach to ICU patients

## Preload

**How to check it ?**

# Acute Cardio-Vascular Failure

"Cardiac Output" Approach to ICU patients

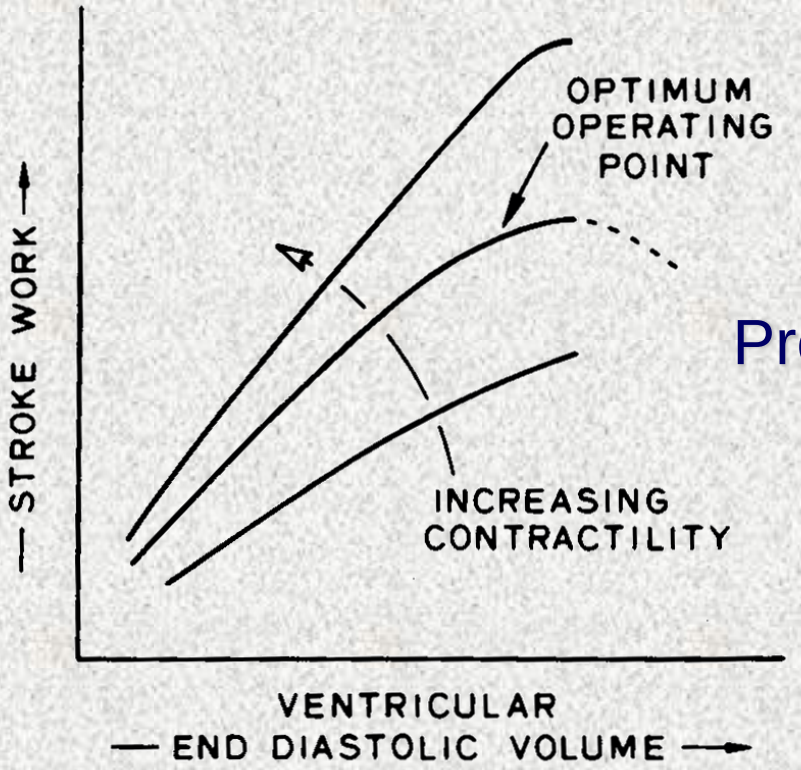



**Preload**

Starling's Law

# Acute Cardio-Vascular Failure

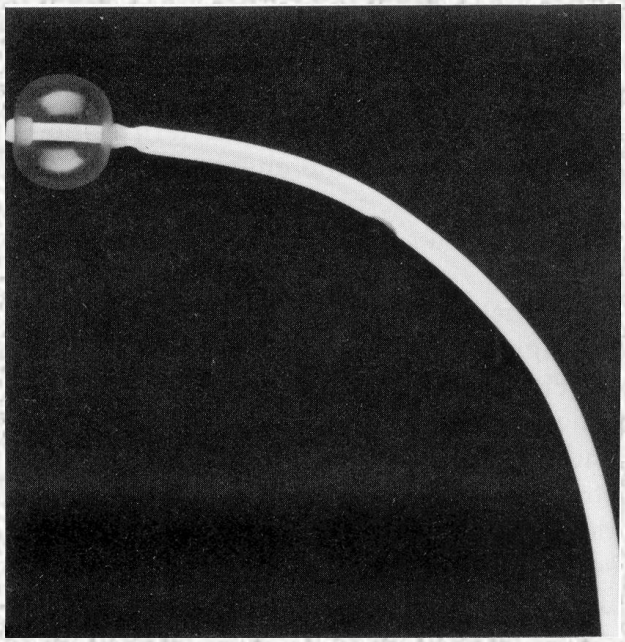
"Cardiac Output" Approach to ICU patients

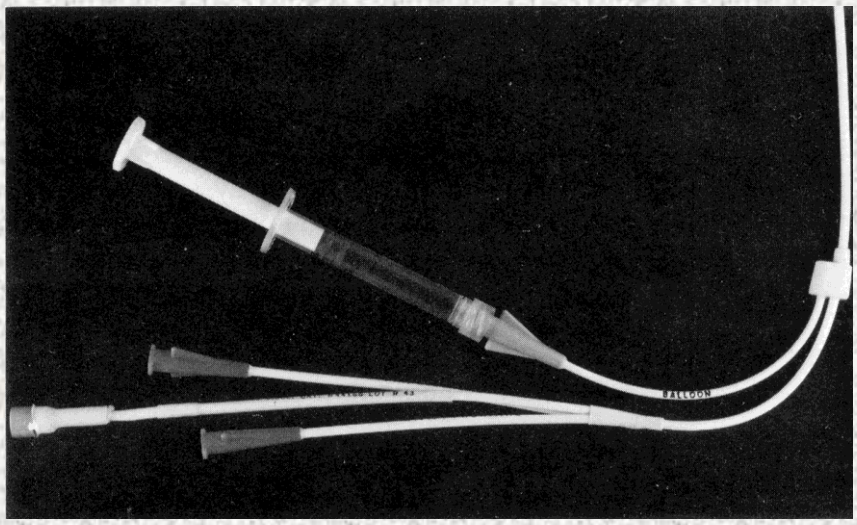



Preload = Intravascular Volume
Status = Venous Return

Starling's Law

# Preload – "left heart"
# Swan - Ganz catheter

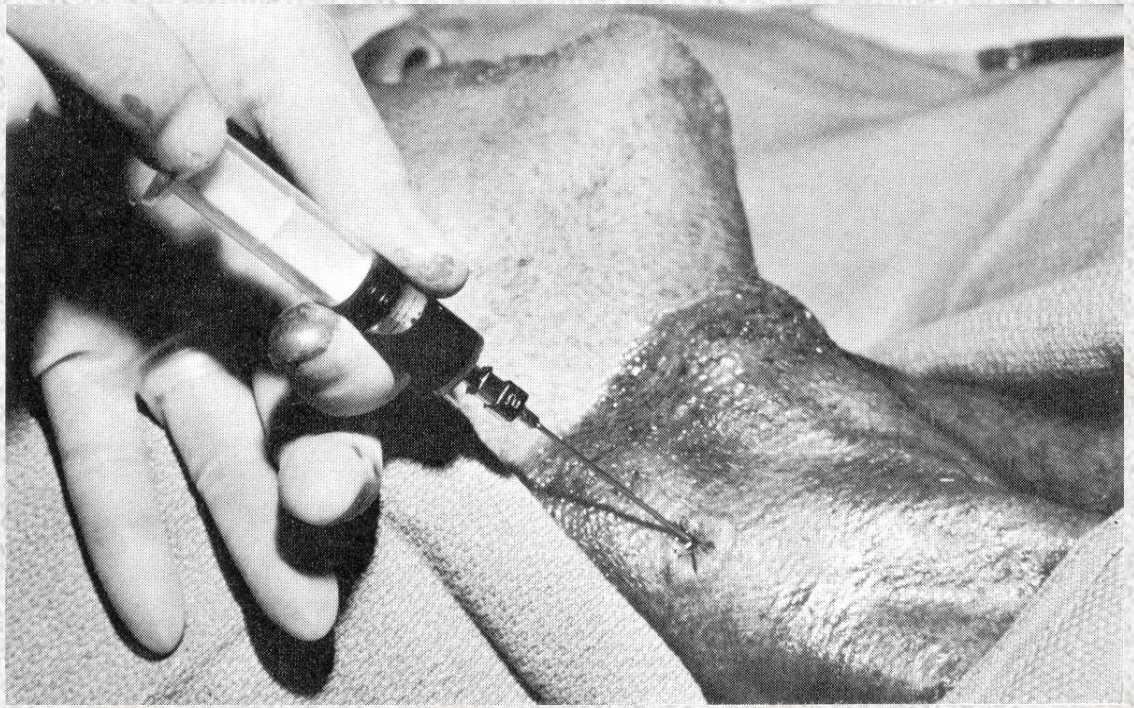




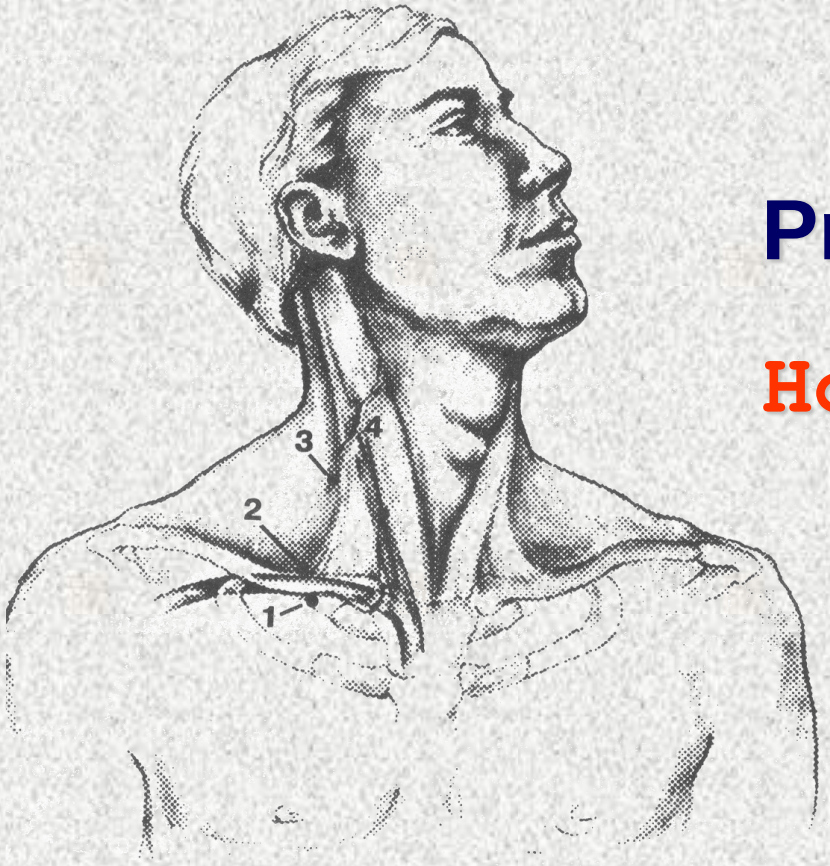
"Cardiac Output" Approach to ICU patients

# Preload

## How to check it ?



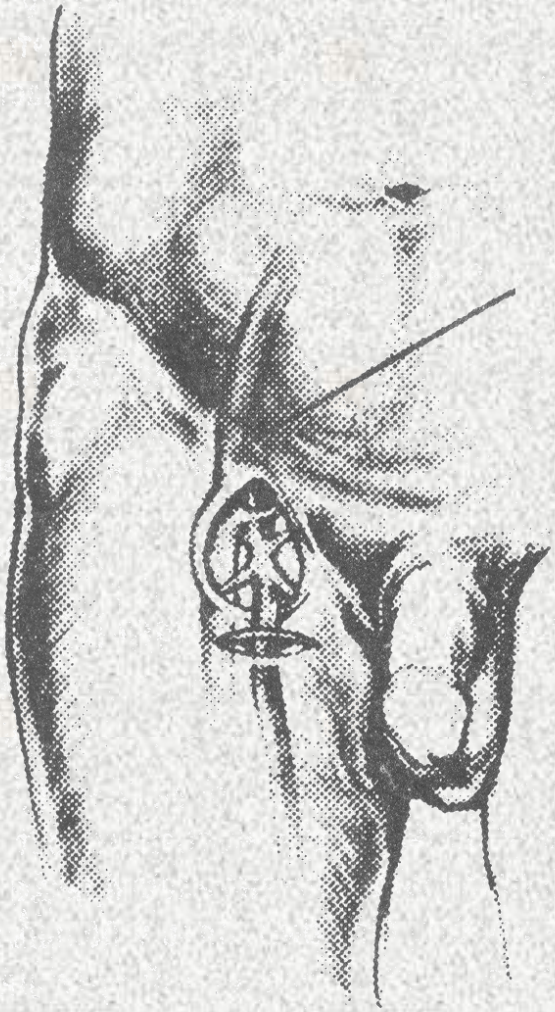
"Cardiac Output" Approach to ICU patients




# Preload

## How to check it ?

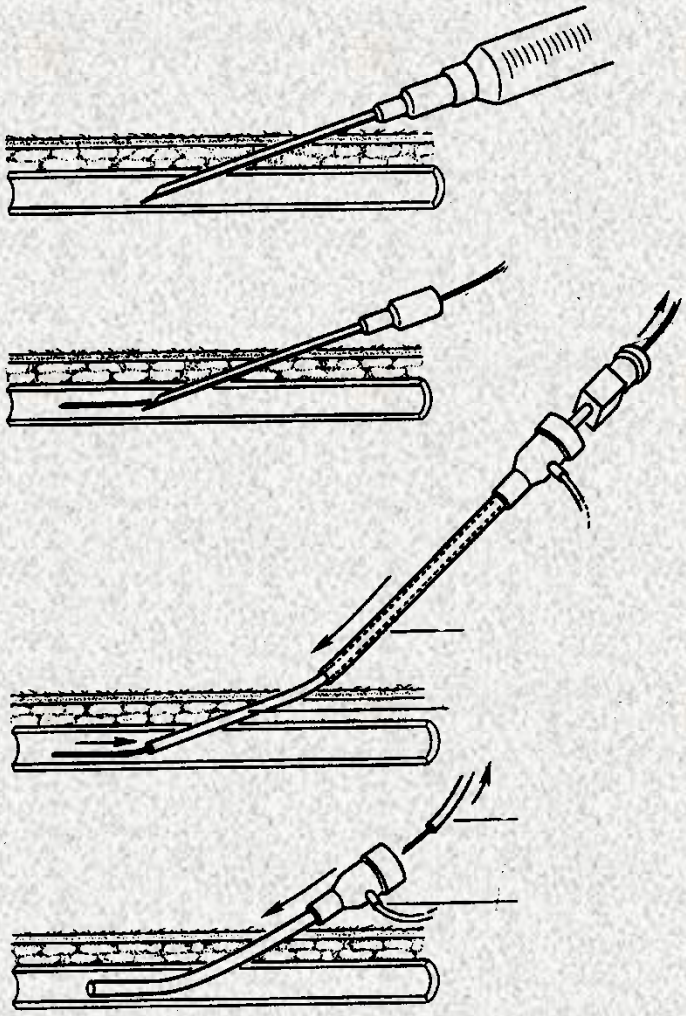
"Cardiac Output" Approach to ICU patients



# Preload

## How to check it ?

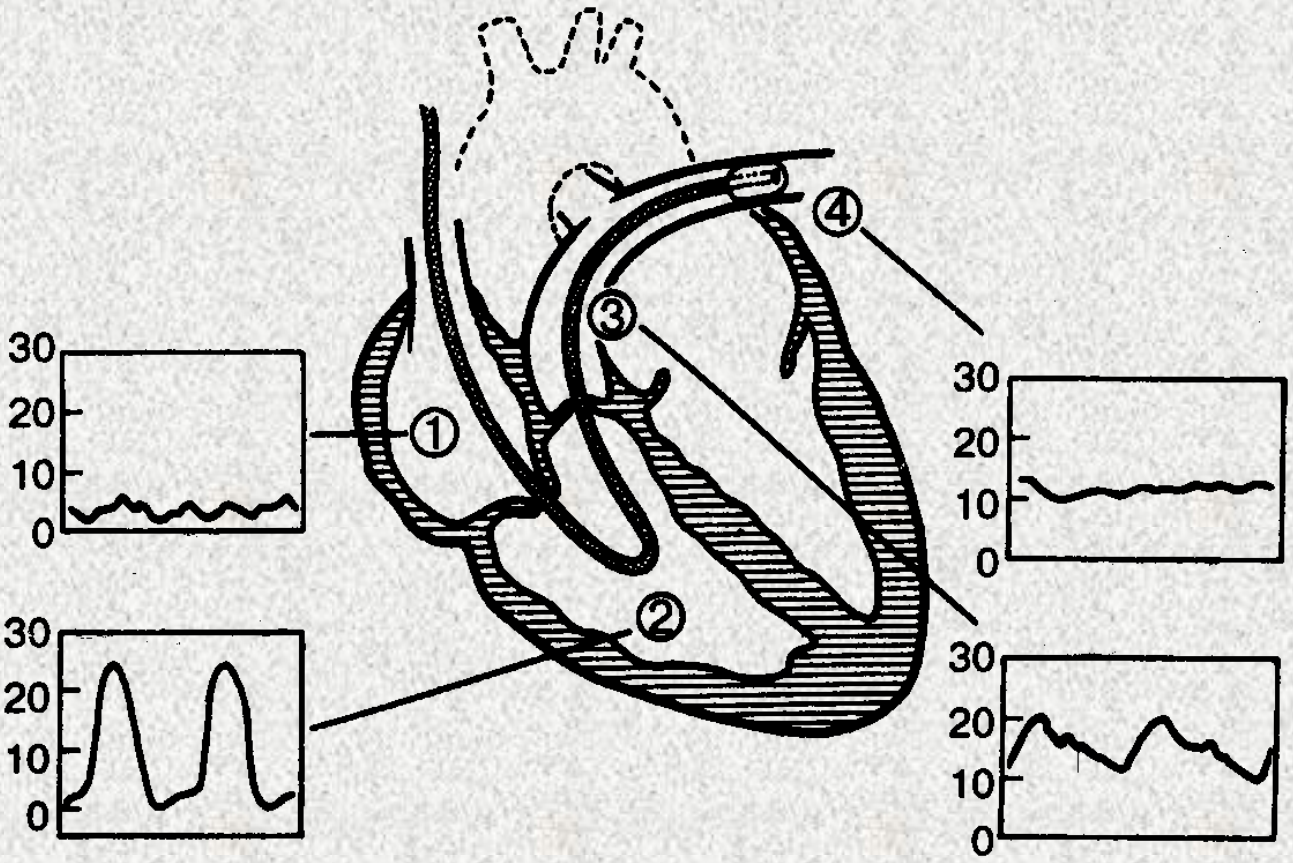
"Cardiac Output" Approach to ICU patients



# Preload

## How to check it ?

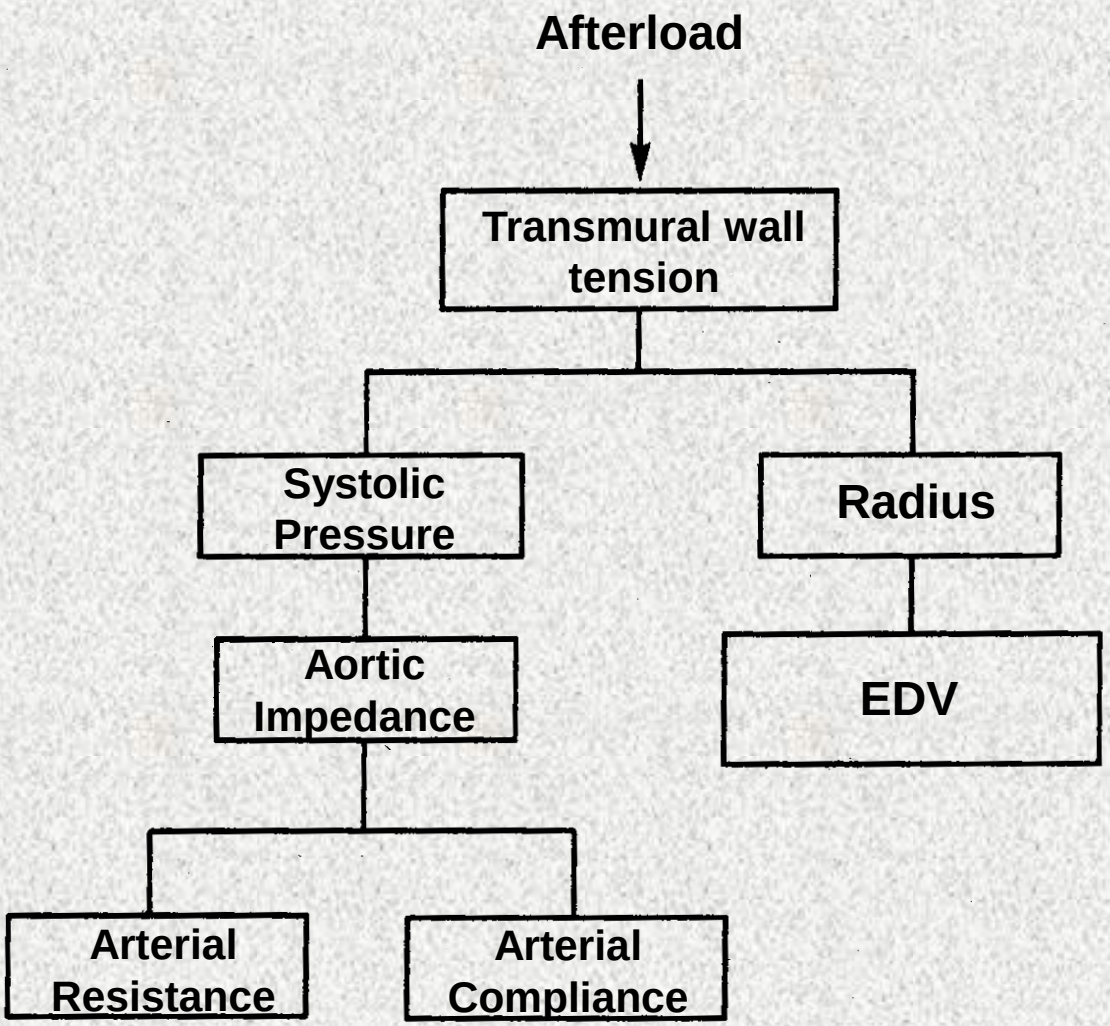
# Preload – "left heart" advancing Swan - Ganz catheter



# Preload – CVP & PCWP

# Afterload – Vascular Resistance?

## "Cardiac Output" Approach to ICU patients

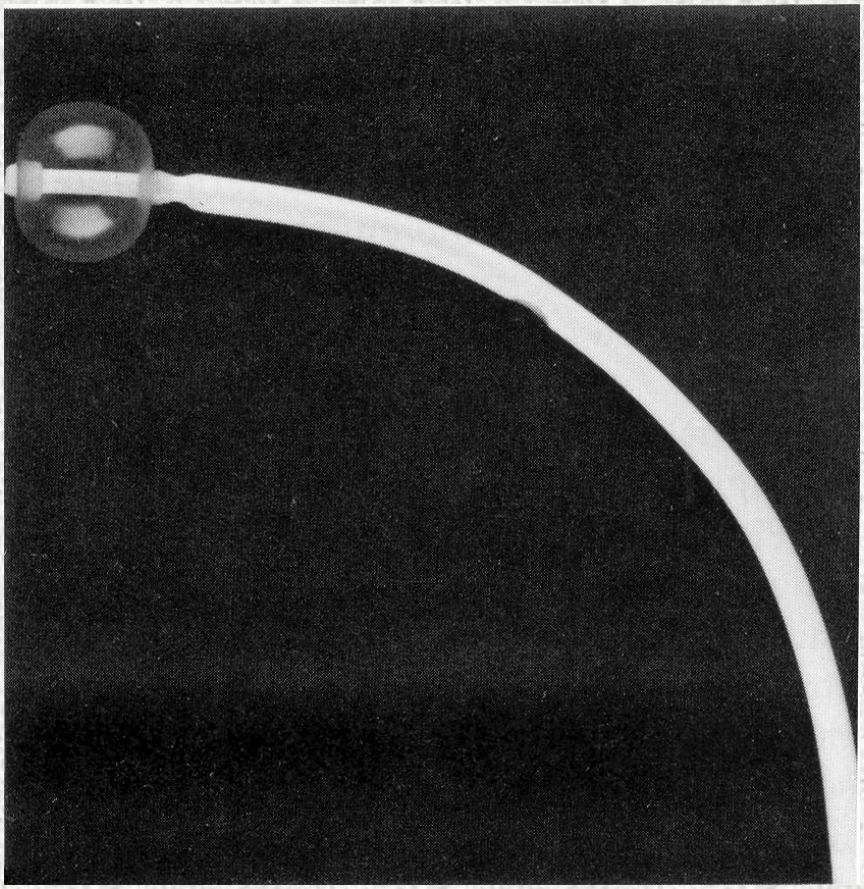


Cardiac Output = Stroke Volume x HR (l/min)

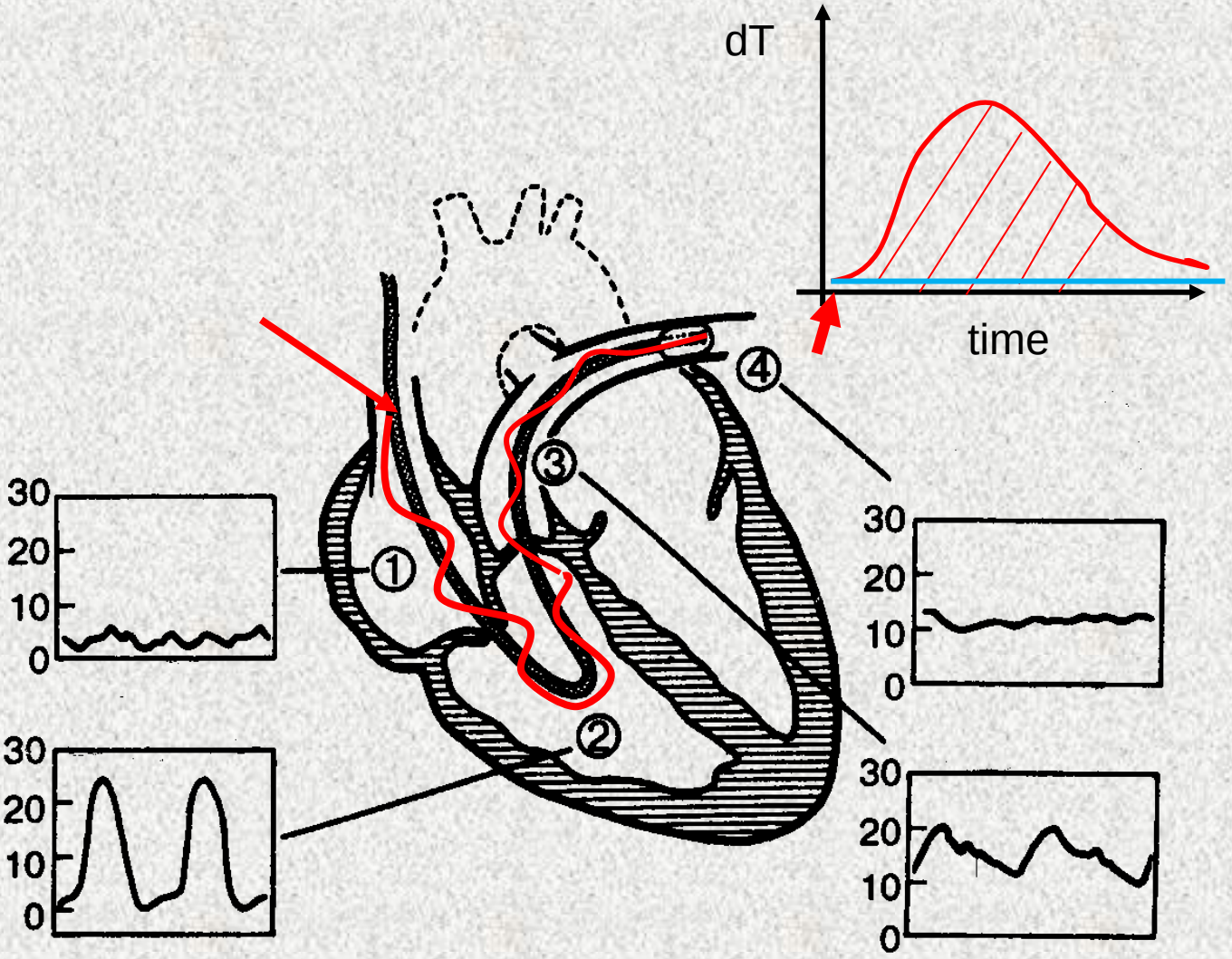
Cardiac Index = CO/BSA (l/min/m2)

Contractility – Stroke Work Index (LV & RV)

# Measuring Cardiac Output



# Measuring Cardiac Output



"Cardiac Output" Approach to ICU patients

# Heart Rate and Rhythm

"Cardiac Output" Approach to ICU patients

# Myocardial Compliance

## "Cardiac Output" Approach to ICU patients

# Determinants of Cardiac Output (CO)

1. **Preload** (CVP, PCWP)

- **Afterload** (Vascular Resistance S&P)
- **Myocardial Contractility** (SWI, CO)
- **Heart Rate & Rhythm (ECG)**
- **Compliance**

## "Cardiac Output" Approach to ICU patients

# MANAGEMENT

**The main goal is optimization of the Cardiac Output determinants**

## "Cardiac Output" Approach to ICU patients

# MANAGEMENT

- **Preload** (Volume Replacement /Optimization)
- **Afterload** (Optimize Vascular Resistance – Vascular Drugs )
- **Myocardial Contractility** (Increase Contractility)
- **Heart Rate & Rhythm** (expectative)
- **Compliance ?**

## "Cardiac Output" Approach to ICU patients

# Vasodilators

| DRUG | SUGGESTED CONCENTRATION FOR CONTINUOUS INTRAVENOUS INFUSION | USUAL BEGINNING DOSE | USUAL DOSE RANGE |
|---|---|---|---|
| Sodium Nitroprusside | 50 mg/250 ml; 200 μg/ml | 0.3–1.0 μg/kg/min | 0.5–5.0 μg/kg/min* (35–350 μg/min) |
| Nitroglycerin | 50 mg/250 ml; 200 μg/ml | 0.5–1.5 μg/kg/min | 0.5–5.0 μg/kg/min (35–350 μg/min) |
| Phentolamine | 25 mg/250 ml; 100 μg/ml | 50 μg/min | 50–500 μg/min |
| Trimethaphen | 500 mg/250 ml; 2 mg/ml | 0.2 mg/min | 0.2–6.0 mg/min |

## "Cardiac Output" Approach to ICU patients

# Vasopressors

| DRUG | SUGGESTED CONCENTRATION FOR CONTINUOUS INTRAVENOUS INFUSION | IV INFUSION RATE | IV BOLUS DOSE | IM DOSE |
|---|---|---|---|---|
| Epinephrine | 1 mg/250 ml; 4 μg/ml | 2–20 μg/min | 0.3–1.0 mg* | † |
| Norepinephrine | 4 mg/250 ml; 16 μg/ml | 2–16 μg/min | | |
| Phenylephrine | 10 mg/250 ml; 40 μg/ml | 10–50 μg/min | 100–400 μg | |
| Methoxamine | | | 2–10 mg | 10–20 mg |
| Ephedrine | | | 5–25 mg | 25–50 mg |
| Metaraminol | 100 mg/250 ml; 400 μg/ml | 50–500 μg/min | 0.5–5.0 mg | 2–10 mg |
| Mephentermine | 30 mg/250 ml; 120 μg/ml | ? | 5–15 mg | 15–30 mg |

## "Cardiac Output" Approach to ICU patients

# Inotropic Agonists

| AGENT | RECEPTOR | RECOMMENDED DOSAGE |
|---|---|---|
| Epinephrine | β | 1–2 μg/min |
| | α, β | 2–10 μg/min |
| | α | >10 μg/min |
| Norepinephrine | α, β | 1–15 μg/min |
| Isoproterenol | β | 1–4 μg/min: titrate to heart rate |
| Dopamine | Dopaminergic, β | 1–10 μg/kg/min |
| | α | >10 μg/kg/min |
| Dobutamine | β | 1–10 μg/kg/min |
| Metaraminol | Indirect (α, β) | 1–10 mg IV<br>5–10 mg IM<br>25–30 mg PO |
| Ephedrine | Direct/indirect (α, β) | 2.5–20 mg IV<br>15–50 mg IM<br>15–50 mg PO |

## "Cardiac Output" Approach to ICU patients

### Hemodynamic Dose Response to Dopamine

| DOSE (μg/kg/min) | PREDOMINANT RECEPTOR | RESPONSE |
|---|---|---|
| 1–3 | Dopaminergic | Renal and mesenteric vasodilation |
| 1–10 | $\beta_1$ | ↑ Contractility<br>↑ Heart rate as dose increases |
| >10 | α | ↑ Vasoconstriction as dose increases |

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AHF-Readings

https://www.dropbox.com/s/awhik2aajl6w9nj/AHF_Readings_definitiv%20%281%29.pdf?dl=0

THE END