Non invasive Cardiac Output monitoring

Non invasive / Minimally invasive hemodynamic monitoring techniques

- Thoracic electrical bioimpedance
  - Pletismografia basata sulle variazioni pulsatili della resistenza elettrica del torace durante il ciclo cardiaco
- Modified Fick techniques
- Pulse wave analysis
- Doppler techniques

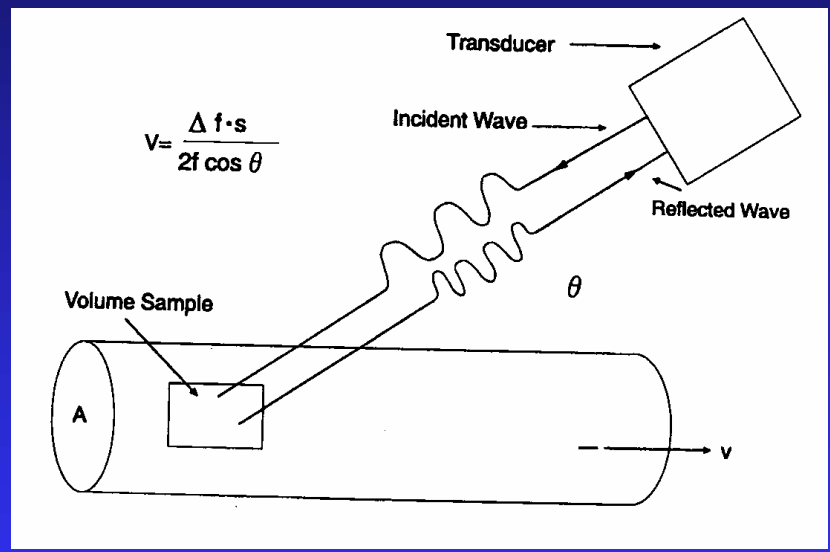
Doppler esofageo

La velocità del flusso ematico in aorta discendente è calcolato in base all'effetto Doppler da un trasduttore sito in esofago.

Vantaggi

Relativamente noninvasivo.

Risposta rapida a variazioni di CO



Svantaggi

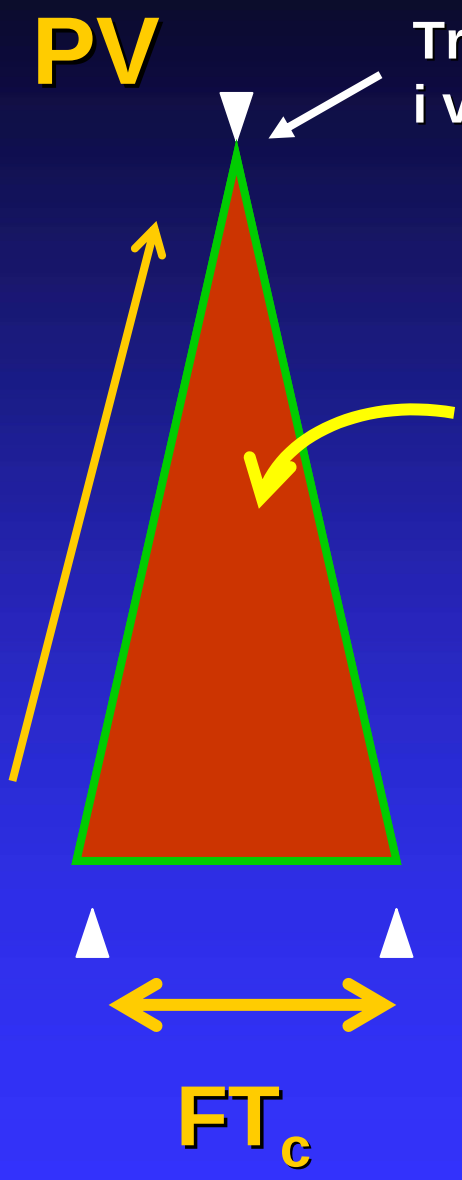
Difficile in paz svegli.

Indispensabile il corretto posizionamento della sonda.

Necessaria la calibrazione con COtd o

la stima del diametro Aortico da un nomogramma

Misura il flusso nell'aorta discendente (descending aortic flow / total CO= cost)



Stroke Distance

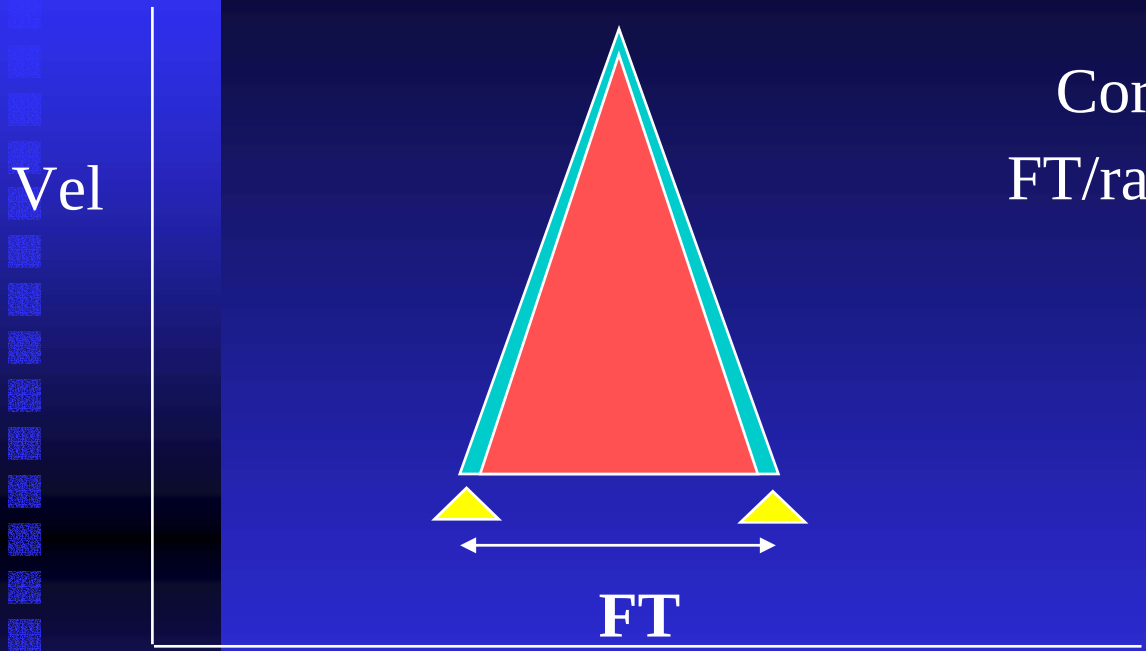
Area sotto la curva

= Distanza percorsa da una colonna di sangue

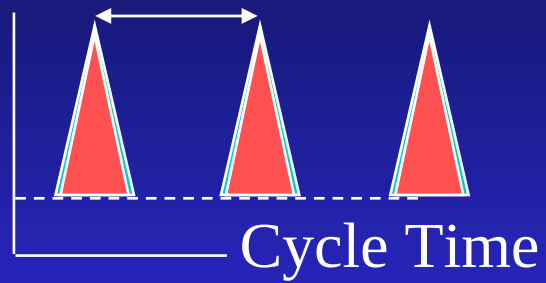
Tempo di Flusso corretto

= FT/ √Tempo di ciclo

Doppler trans-esofageo
FLOW TIME

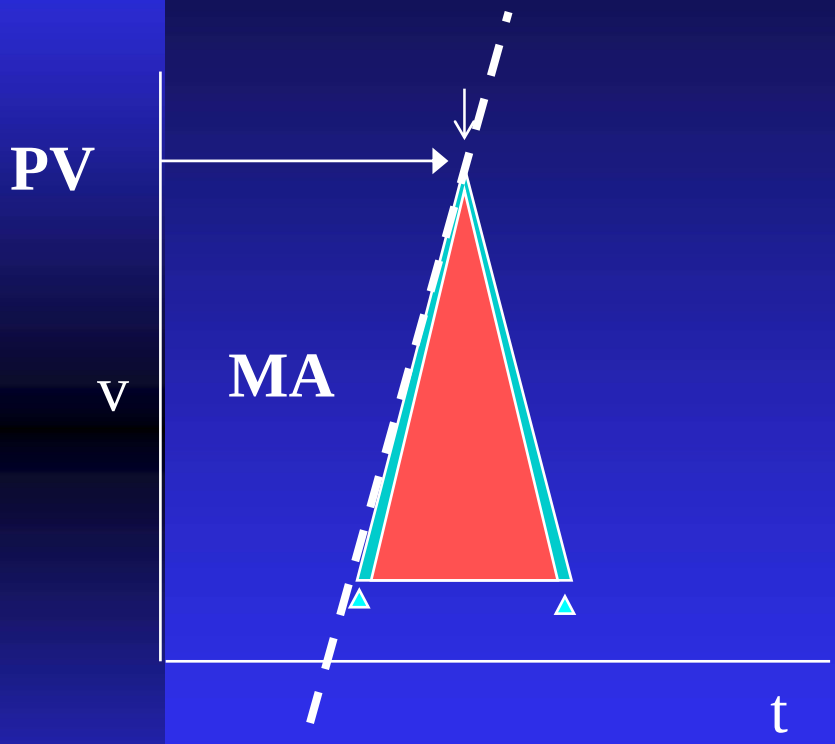


Corrected flow time (**FTc**) =
FT/radice quadra di intervallo RR



- **tempo di flusso di sangue in aorta**
- **in fase sistolica**
- **circa 30% del ciclo cardiaco**
- **FT è inversamente correlato a HR**
- **FTc normalizza FT per HR**
- **FTc direttamente correlato precarico**
- **Valori di FTc 330-360 ms**

Doppler trans-esofageo
PEAK VELOCITY
MEAN ACCELERATION



- **PV: velocità di flusso più elevata**
- **MA: derivata prima fase ascendente**

- **PV e MA inversamente correlati all'età**

20 anni 90-120 cm/sec

50 anni 70-100 cm/sec **per PV**

70 anni 50-80 cm/sec

- **PV e MA direttamente correlato precarico e contrattilità**

- **PV e MAinversamente correlato post-carico**

Come determino CO?

1. VELOCITA' X TEMPO = SPAZIO percorso *

* *SPAZIO percorso da una colonnina di sangue durante una sistole = STROKE DISTANCE (SD)*

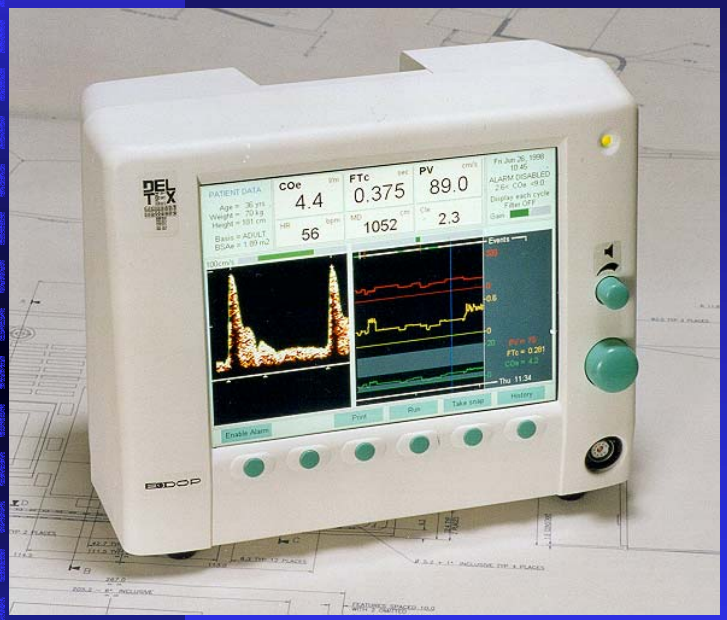
2. SD x Sez. Aortica* = GITTATA SISTOLICA (SV)

**stimata*

3. SV X HR = GITTATA CARDIACA (CO)

Doppler esofageo

Monitor - Cardio Q™



Monitor Hemosonic

Doppler ultrasound

Aortic cross sectional area assumed from nomograms

Transesophageal echo-aortography and Doppler ultrasound (dual echo-Doppler)

Parametri Emodinamici

CardioQ

Hemosonic

MISURATI

- FTc Flow Time corrected (msec)
- PV Peak Velocity (cm/sec)
- SD Sistolic Distance (cm)
- MD Minute Distance (cm)
- MA Mean Acceleration (cm/sec^2
- HR Heart Rate (bpm)

LVETc left ventricular ejection time

Max Acc max acceleration

Aortic diameter

ABF aortic blood flow

CALCOLATI

- CO Cardiac Output (l/min)
- CI Cardiac Index (l/min/m$^{2)}$
- SV Stroke Volume (ml)
- SVR Systemic Vascular Resistance (dyne/cm/sec^{-5})

Esophageal Doppler Indications

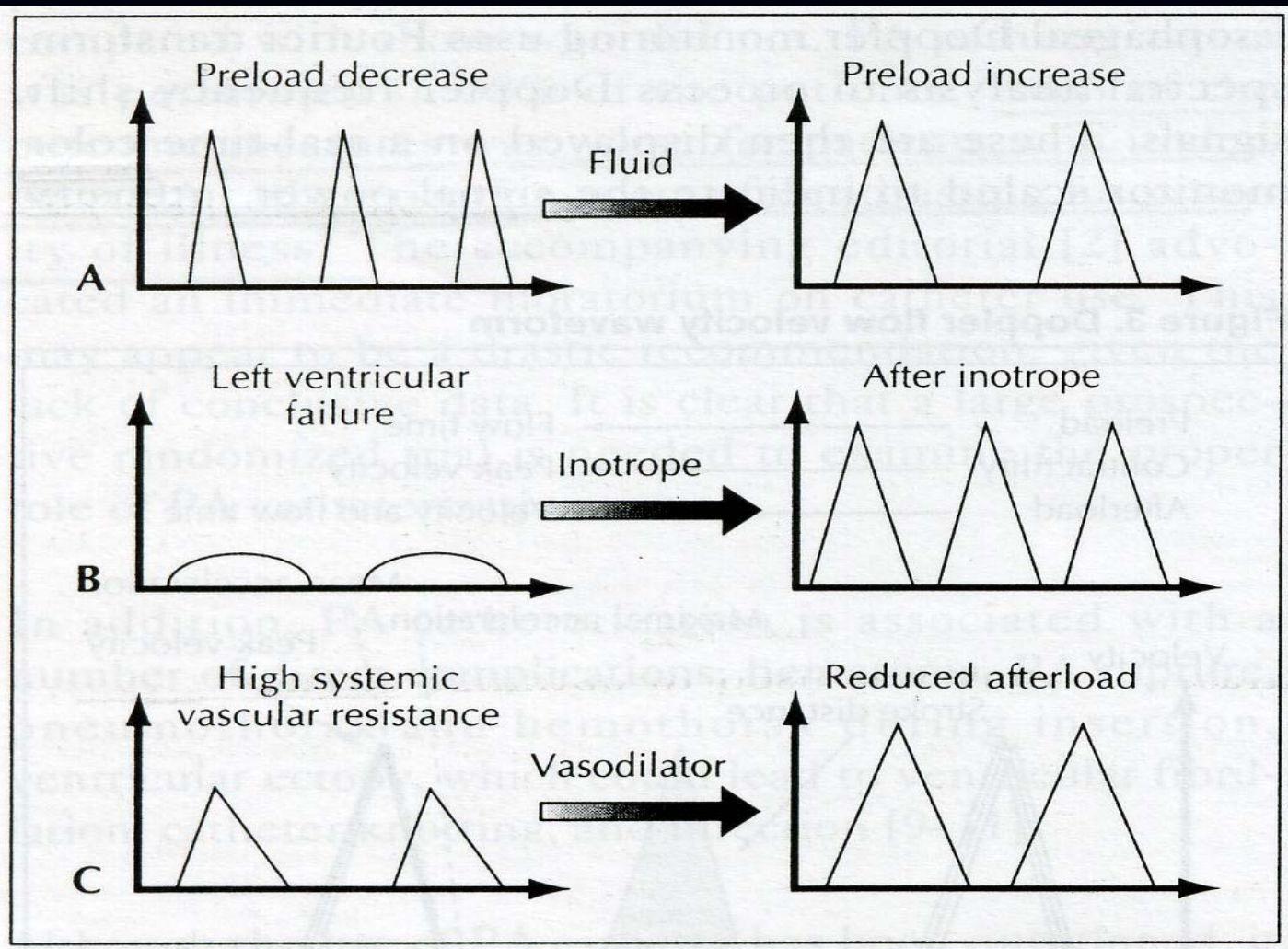
- Moderate to High-risk General Anesthesia
  - major / extensive surgical procedures
  - cardiac patients for non-cardiac surgery
  - elderly patients
  - pediatric patients
  - major trauma
- Intensive Care Units
  - hemodynamically unstable patients
  - post-op requiring hemodynamic monitoring in the OR
  - patients with ARDS
  - multi-organ failure
  - major burns

Doppler Esofageo
Controindicazioni

- Anatomy-related
  - oral/pharyngeal malformations
  - esophageal distortions (strictures, varices, etc.)
  - acute esophageal inflammation
  - esophageal stents
  - proximal aortic coarctation
  - thoracic aortic aneurysm
  - esophageal, pharyngeal, or laryngeal carcinoma

Doppler esofageo
Limitations / Delicate Indications

- Intra-aortic balloon
- Atrial fibrillation (irregular systoles)
- Aortic valve disease



(A) Hypovolemia is indicated by a narrow waveform base (left). Restoration of normovolemia (right) results in a widening of the waveform base and a lengthening of the flow time. **(B)** A poorly contractile left ventricle displays reduced waveform height with abnormally low peak velocity (left). Effective inotropic therapy increases waveform height and restores peak velocity (right). **(C)** Excessive afterload is indicated by both a reduced waveform height and narrowed waveform base (left). Appropriate vasodilation is evidenced by increases in both the peak velocity and flow time (right).

Goal-directed intraoperative fluid administration reduces lenght of hospital stay after major surgery

Tong J. Gan et al., 2002