Preload Assessment

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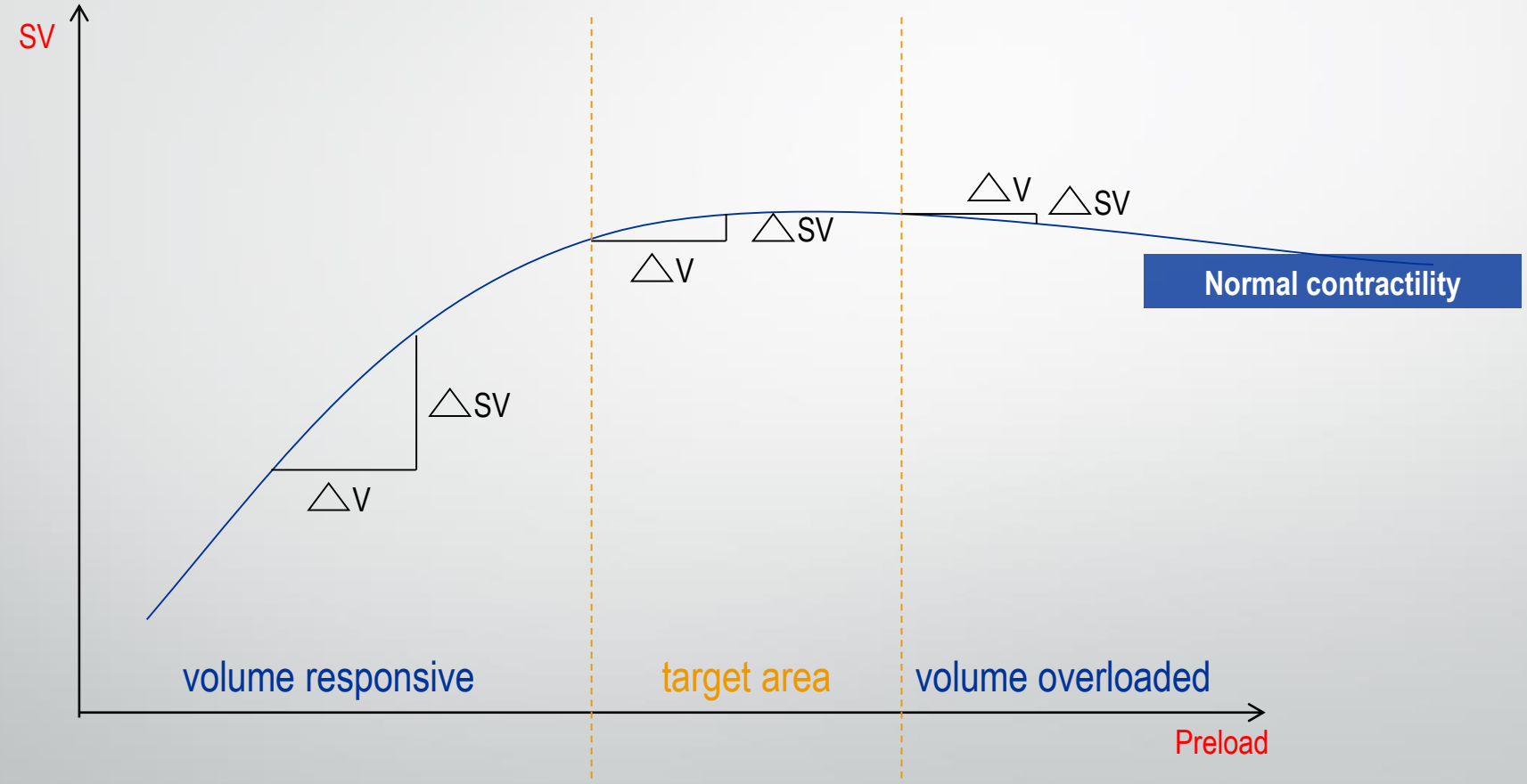
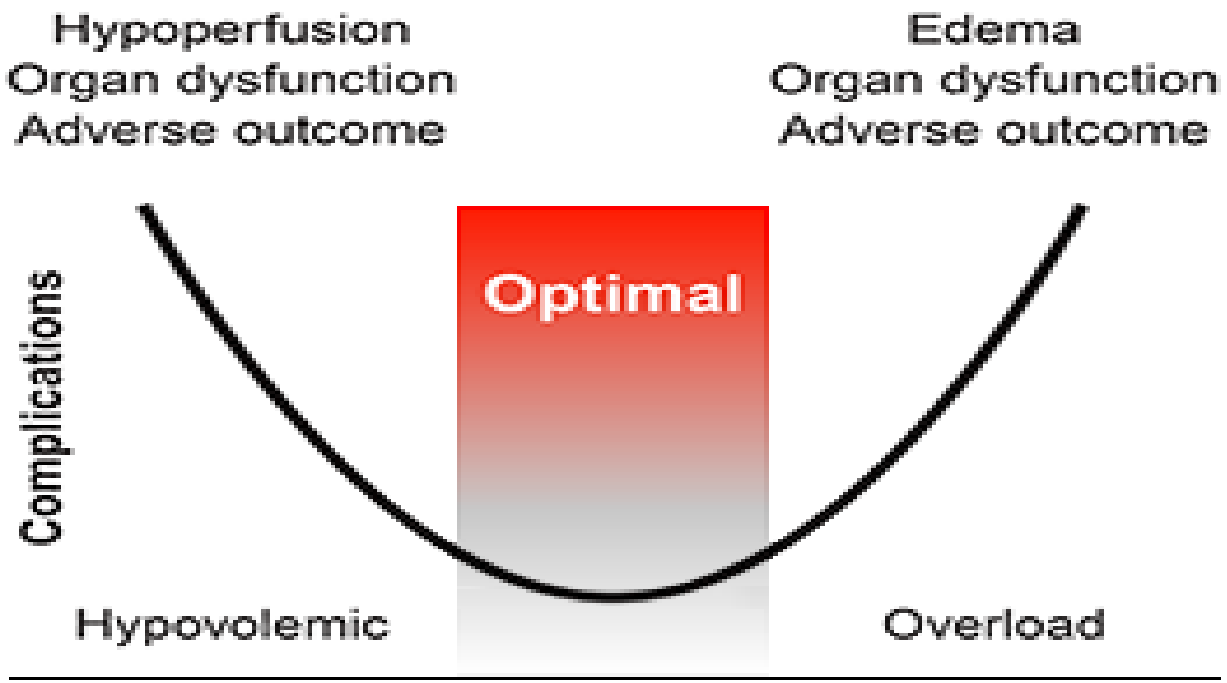
Preload, CO and Frank-Starling Mechanism



Where do you want to be?

Complications from excessive and insufficient volume administration [2,3]



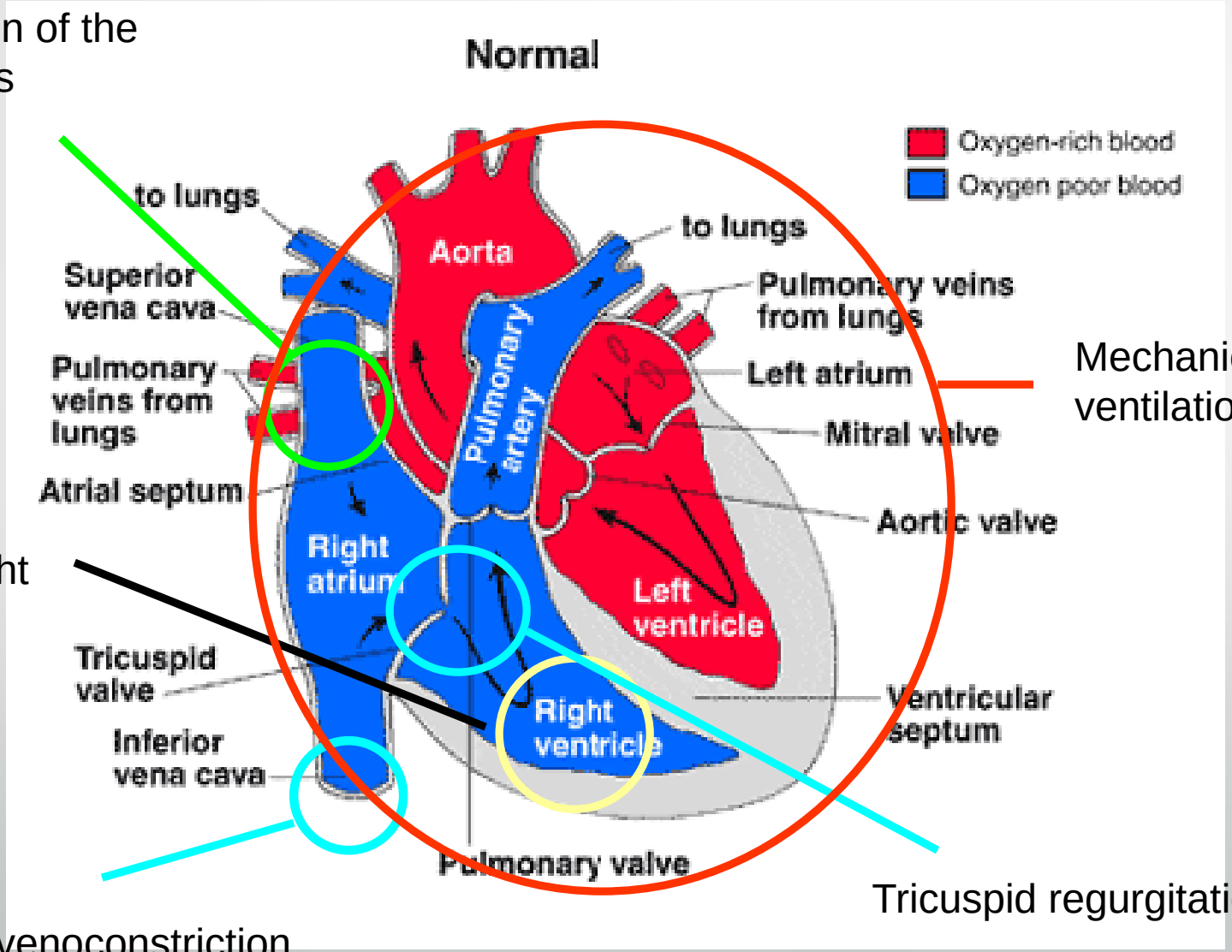
Volume Assessment

- Filling Pressures
- Volumetric Preload Parameters
- Volume Responsiveness

Filling Pressures

Limitation of CVP

Obstruction of the great veins



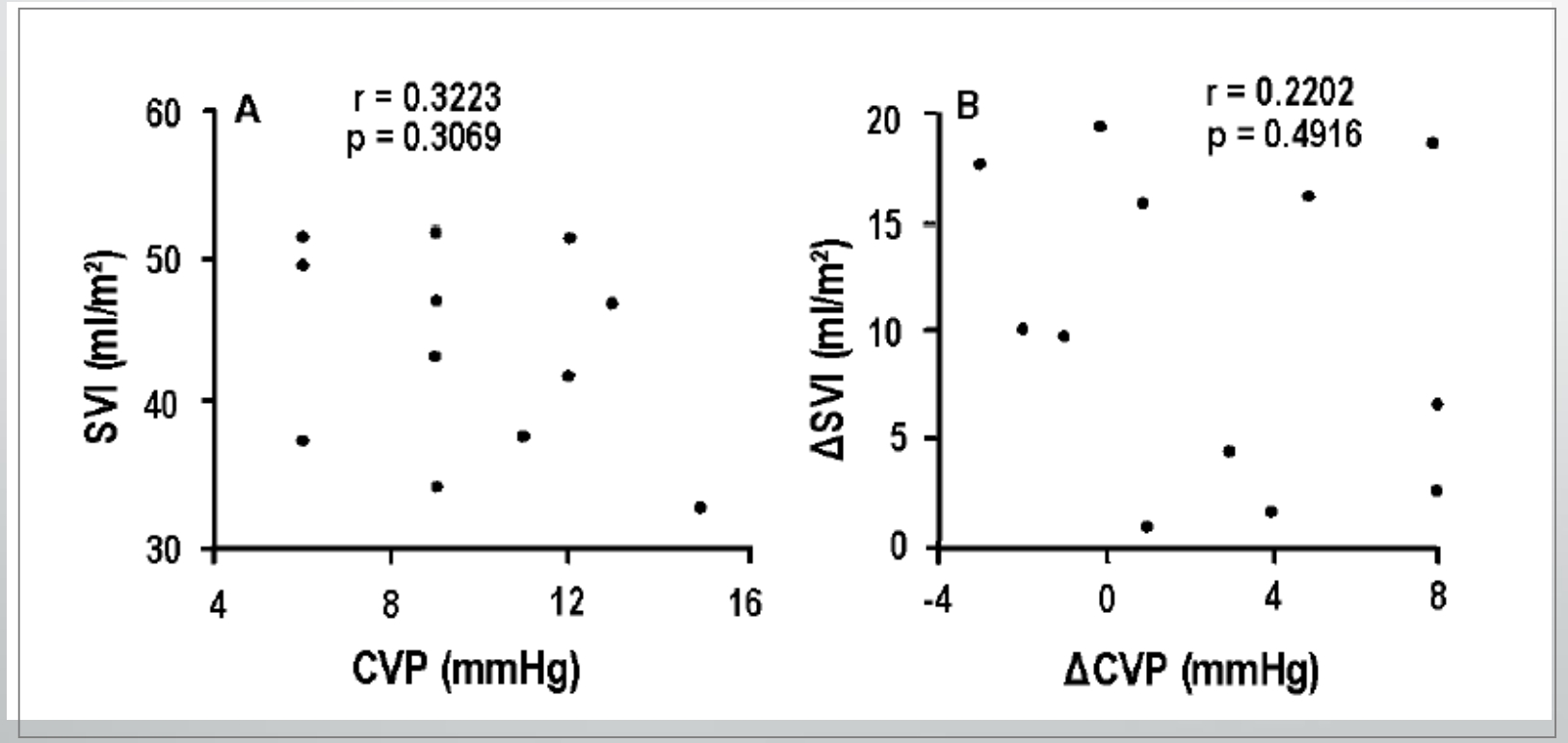
Mechanical ventilation

Decrease right ventricular compliance

Tricuspid regurgitation

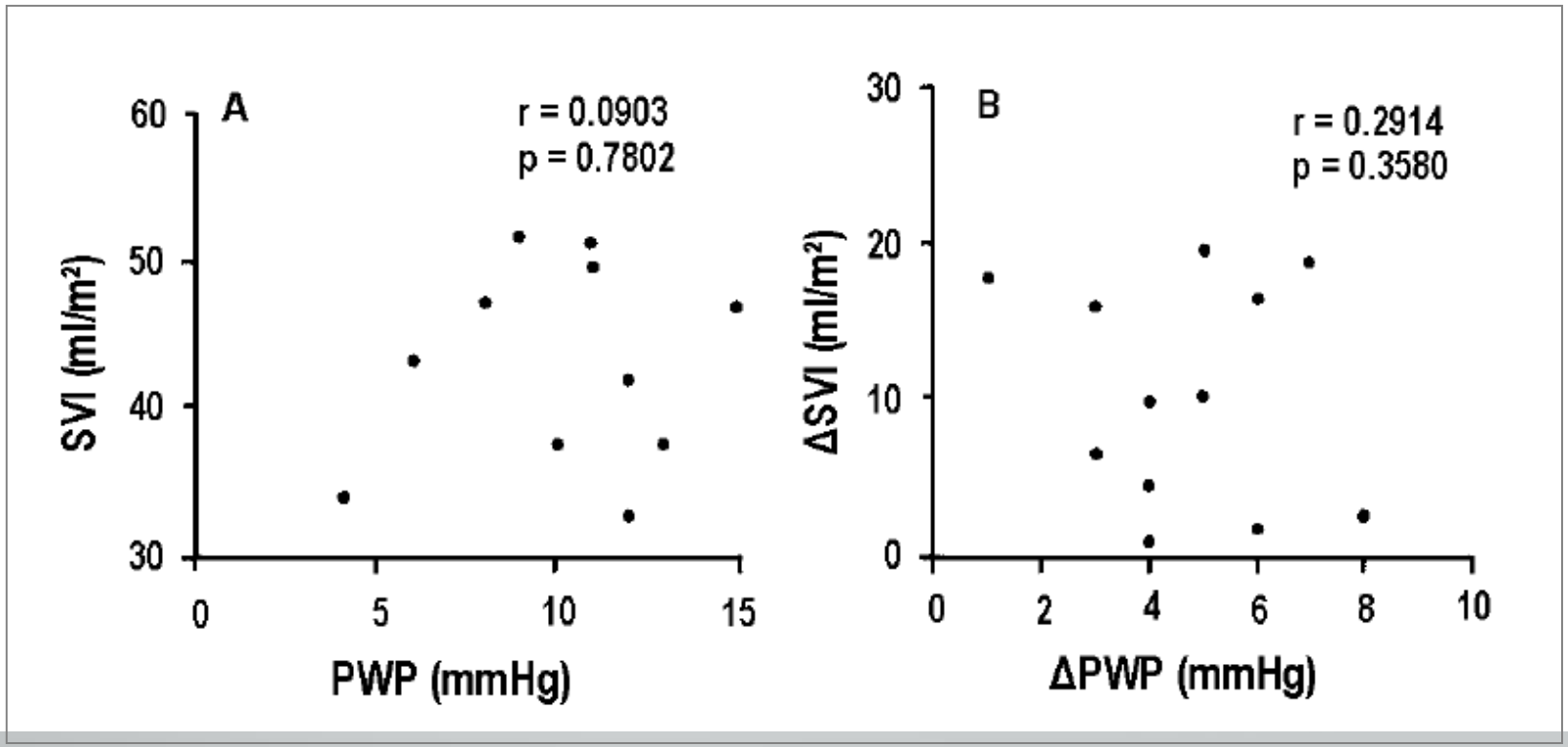
Systemic venoconstriction

Correlation between CVP and Stroke Volume



Kumar et al., Crit Care Med 2004;32: 691-699

Correlation between PCWP and Stroke Volume



Kumar et al., Crit Care Med 2004;32: 691-699

The filling pressures CVP and PCWP do not give an adequate assessment of cardiac preload.

The PCWP is, in this regard, not superior to CVP

Pressure is not volume!

- **Left Ventricular End-diastolic Area**

  LVEDD <25mm or LVEDA<55 mm m2 : Hypololemia

- **Inferior Vena Caval Diameter**

  - **normal :1/5-2/5 c**
  - **If <1/5 cm : Hypovolemia**

Volumetric Preload Parameters

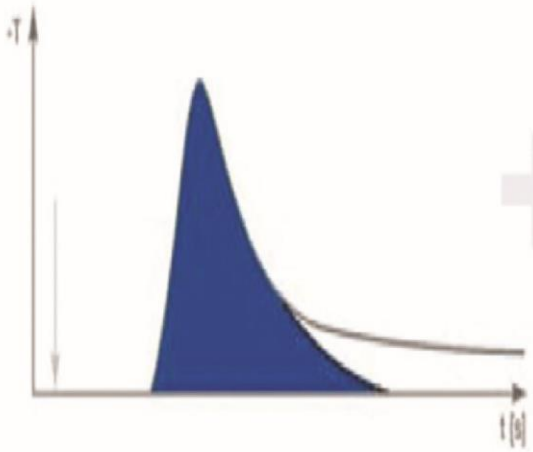
Volumetric parameters

- **GEDV - Global End Diastolic Volume**
- **ITBV – Intra Thoracic Blood Volume**

- **EVLW - Extravascular Lung Water**
- **PVPI - Pulmonary Vascular Permeability Index**

Transpulmonary Thermodilution (TPTD)

- Cold saline is injected into the superior vena cava through a central venous catheter
- An arterial cannula is placed in a major artery (femoral, axillary, or brachial), which has an integrated thermistor
- It measures the change in blood temperature, and computer software is used to plot a thermodilution curve of temperature change over time.

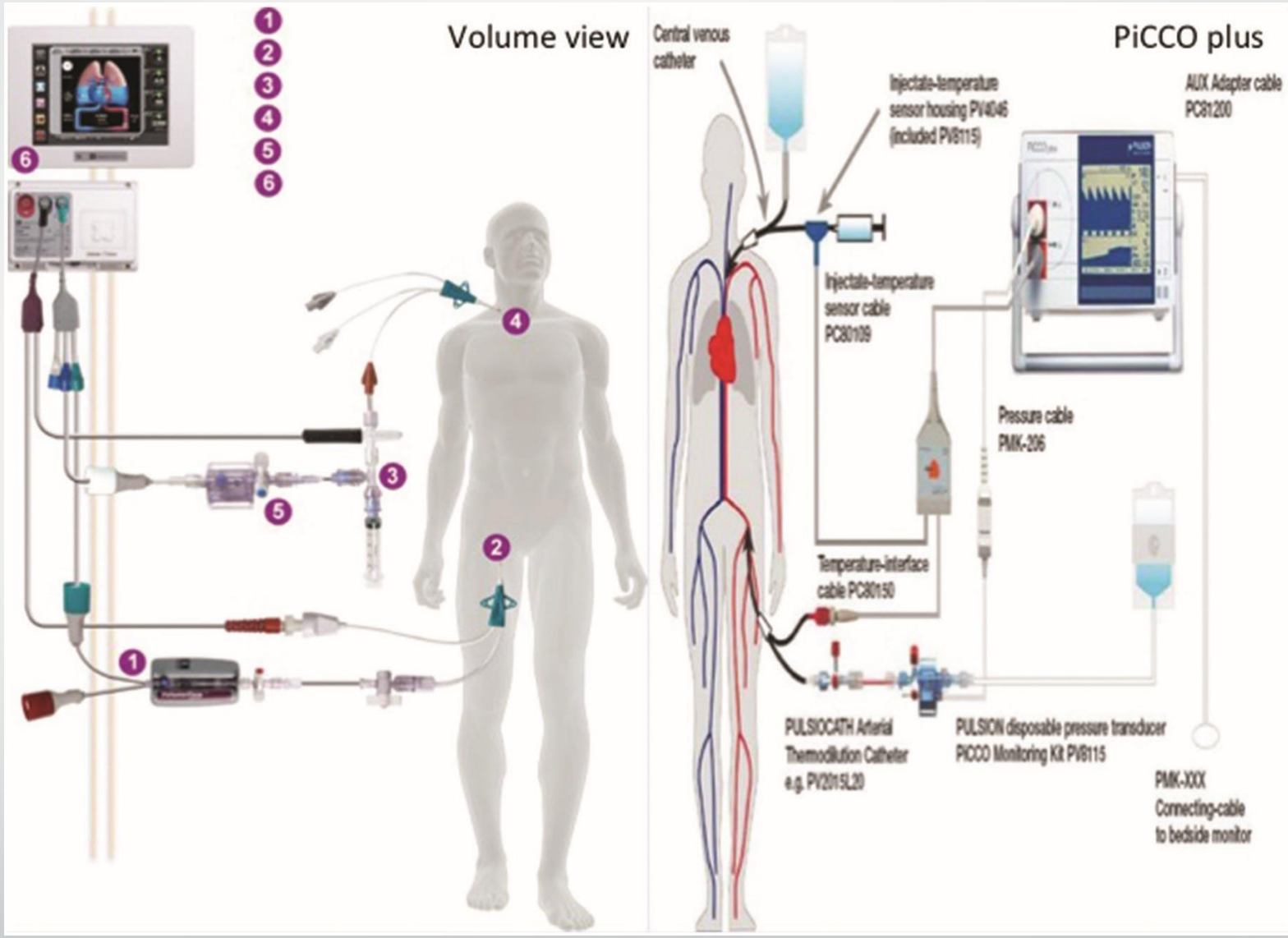


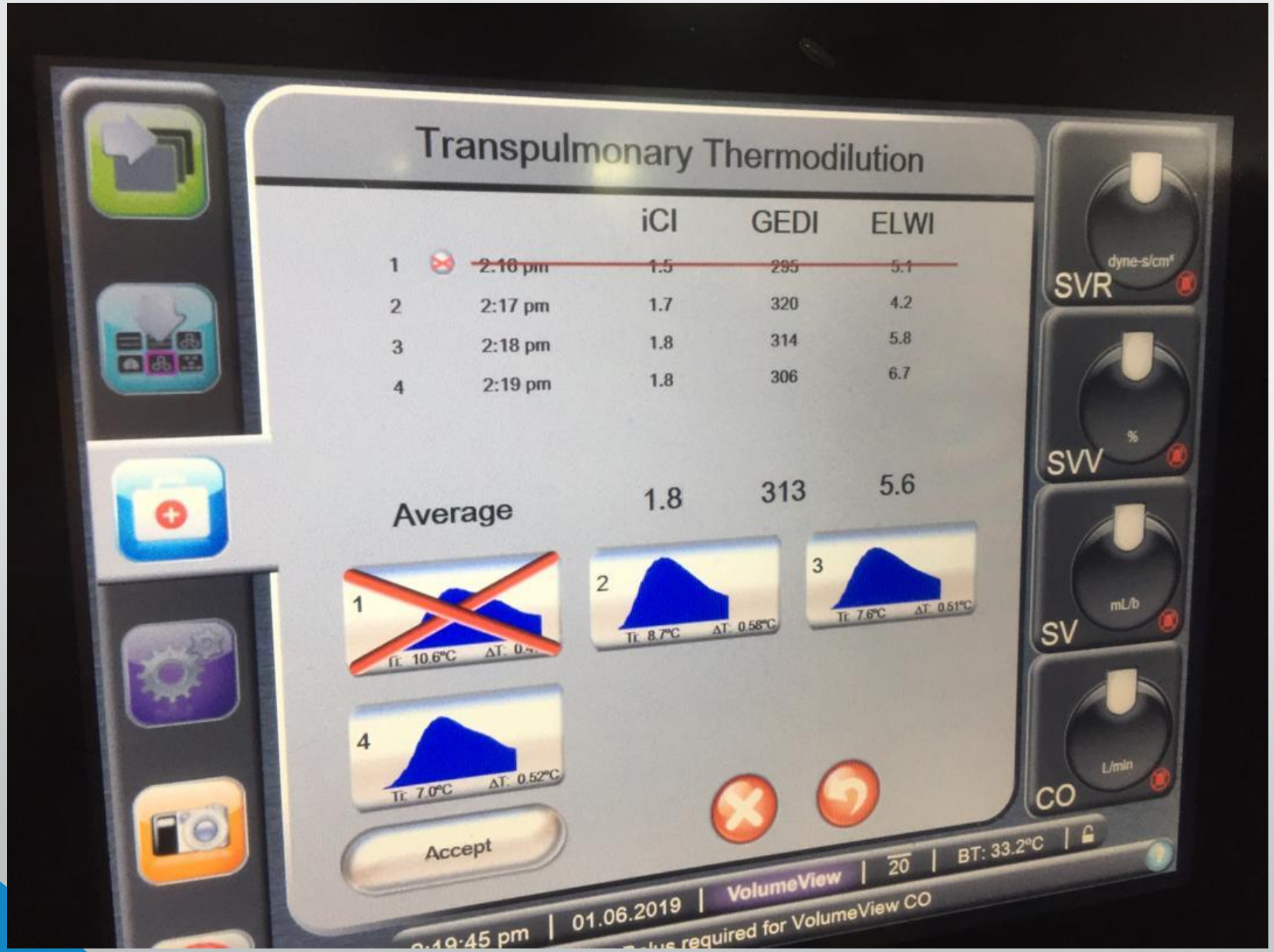
Cardiac output calculation:
Area under the thermodilution curve

$$CO_{TDa} = \frac{(T_b - T_i) \times V_i \times K}{\int \Delta T_b \times dt}$$

T_b = Blood temperature
T_i = Injectate temperature
V_i = Injectate volume
$\int \Delta T_b \times dt$ = Area under the thermodilution curve
K = Correction constant, made up of specific weight and specific heat of blood and injectate

- ✓ EV1000/VolumeView (Edwards Lifesciences, Irvine, CA, USA)
- ✓ PiCCOplus (Pulsion Medical Systems, Germany)

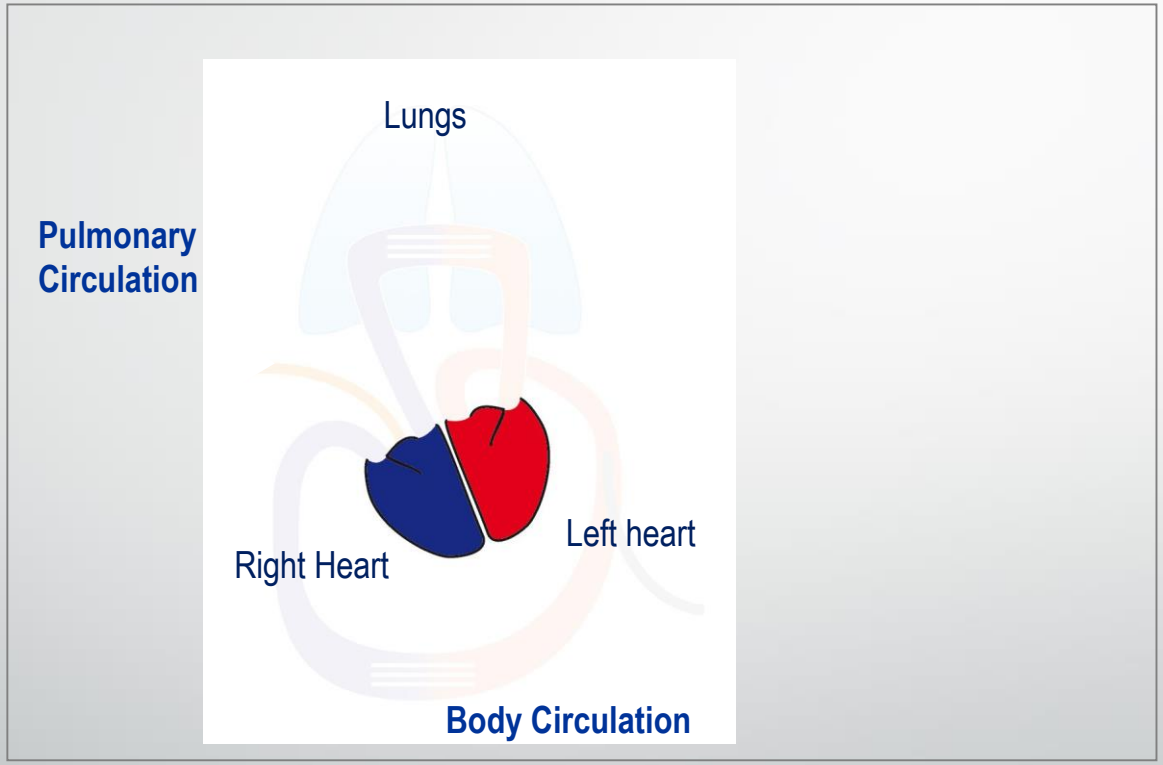



Transpulmonary Thermodilution
iCI
GEDI
ELWI
1
2:18 pm
1.5
295
5.1
2
2:17 pm
1.7
320
4.2
3
2:18 pm
1.8
314
5.8
4
2:19 pm
1.8
306
6.7
Average
1.8
313
5.6
SVR
dyne-s/cm⁵
SVV
%
SV
mL/b
CO
L/min
Accept
01.06.2019
VolumeView
BT: 33.2°C

Restrictions

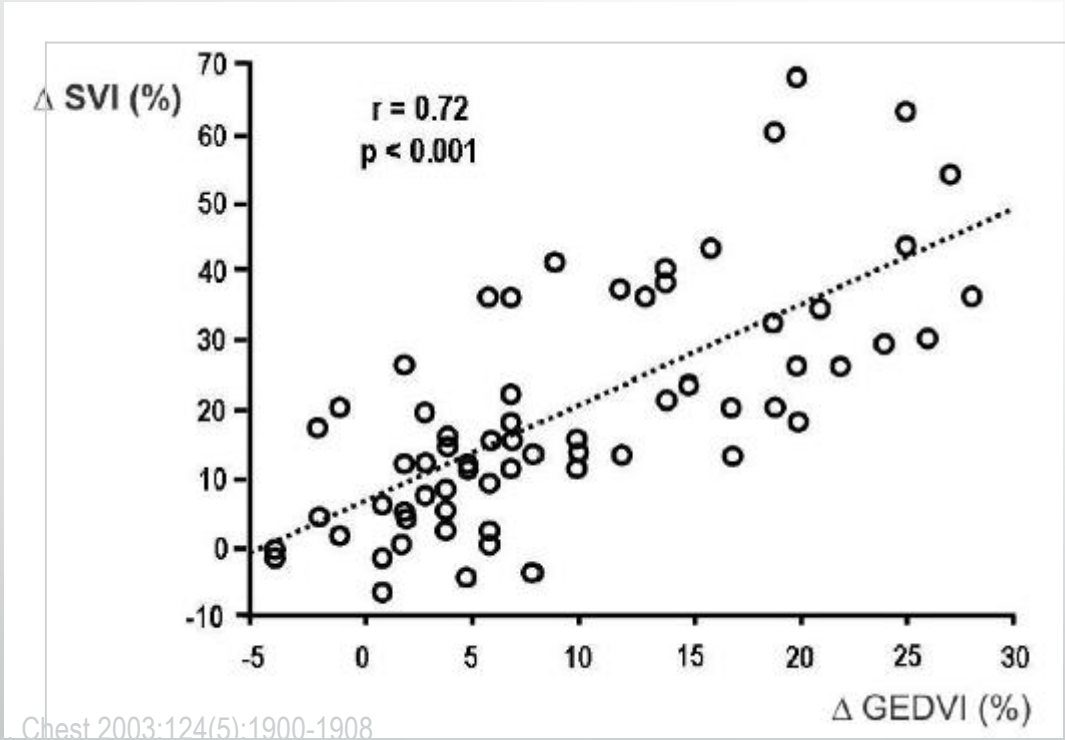
- Transpulmonary thermodilution is vulnerable to errors due to drift and indicator recirculation
- Presence of an intracardiac or intrapulmonary shunt will lead to differing CO measurements
- The magnitude of error produced due to valvular regurgitation cannot be predicted and depends on the site and severity of the regurgitation

GEDV = Global End diastolic Volume



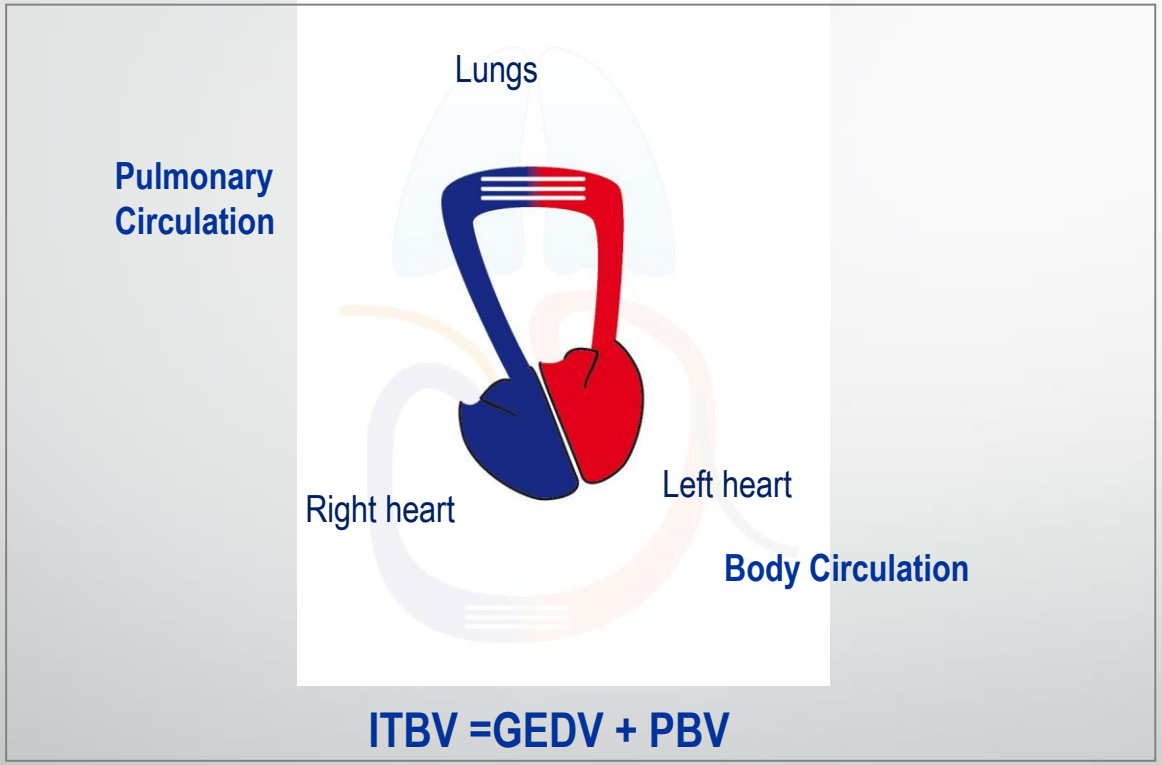
Total volume of blood in all 4 heart chambers

GEDV shows good correlation with the stroke volume



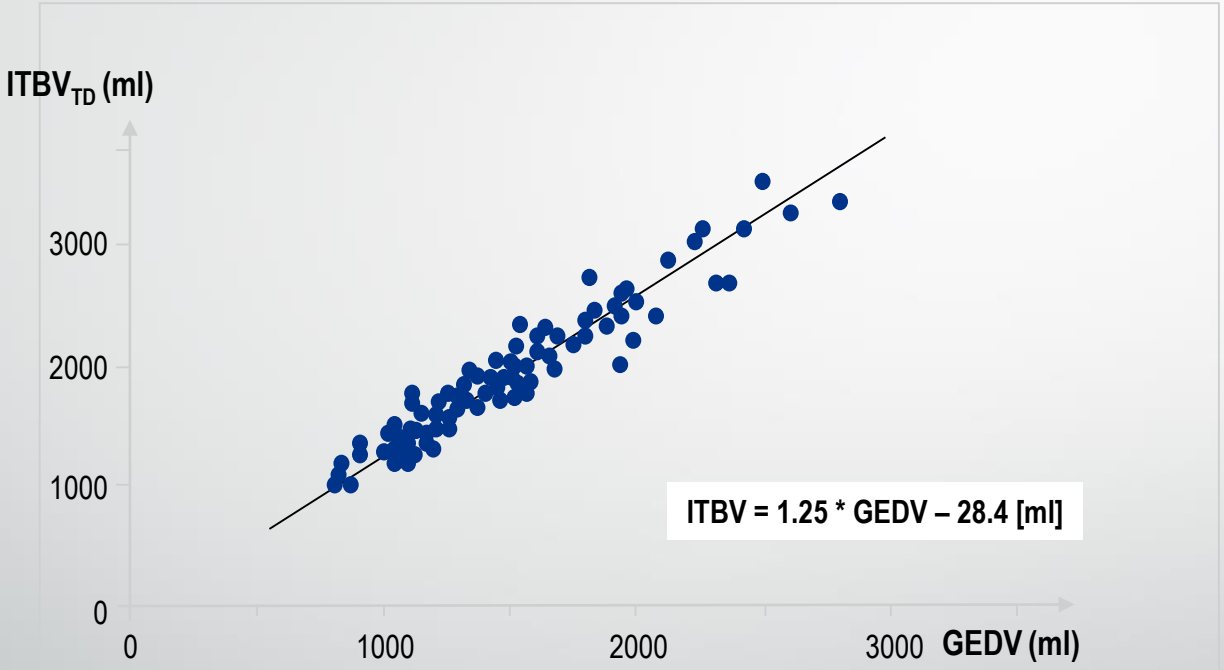
Michard et al. Chest 2003;124(5):1900-1908

ITBV = Intrathoracic Blood Volume



Total volume of blood in all 4 heart chambers plus the pulmonary blood volume

ITBV is normally 1.25 times the GEDV



GEDV vs. ITBV in 57 Intensive Care Patients

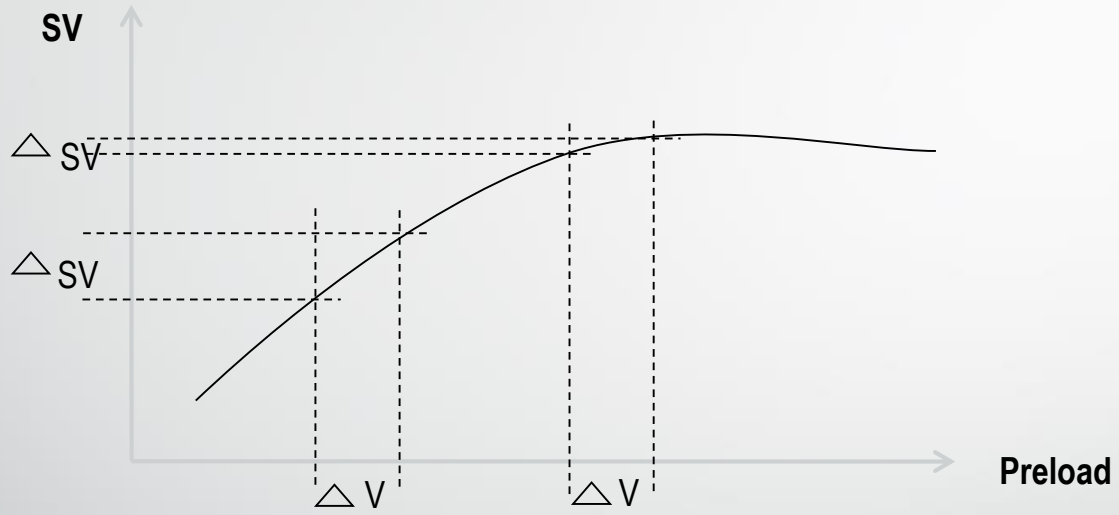
The static volumetric preload parameters GEDV and ITBV

- Are superior to filling pressures for assessing cardiac preload
- Are, in contrast to cardiac filling pressures, not falsified by other pressure influences (ventilation, intra-abdominal pressure)

Volume Responsiveness

Physiology of the dynamic parameters of volume responsiveness

Fluctuations in stroke volume throughout the respiratory cycle



Mechanical Ventilation

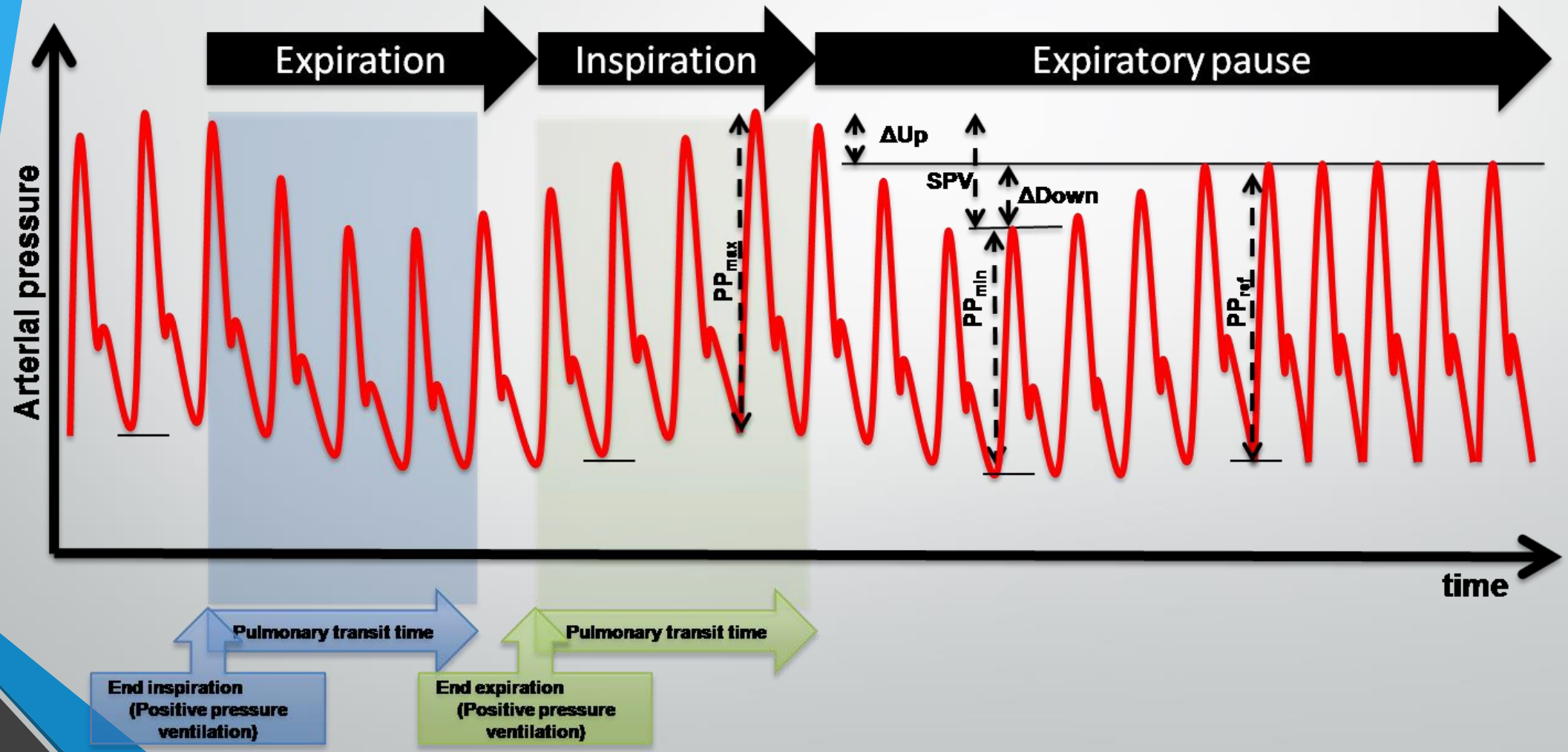
Intrathoracic pressure fluctuations

→ Changes in intrathoracic blood volume

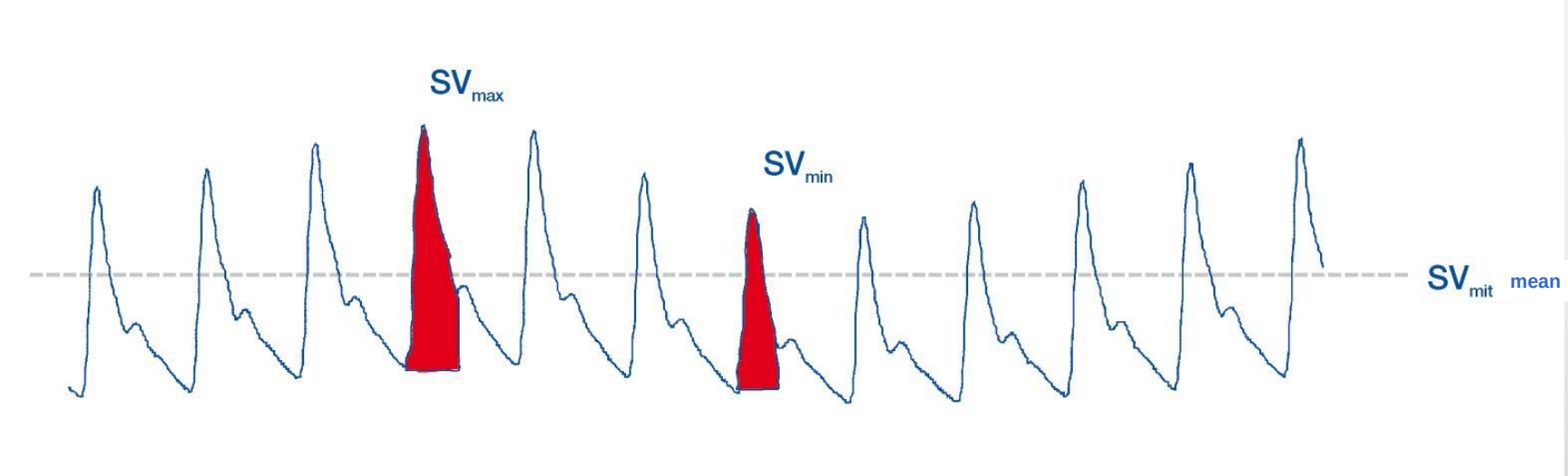
Preload changes

→ Fluctuations in stroke volume

Arterial pressure variation during positive pressure ventilation without spontaneous effort.



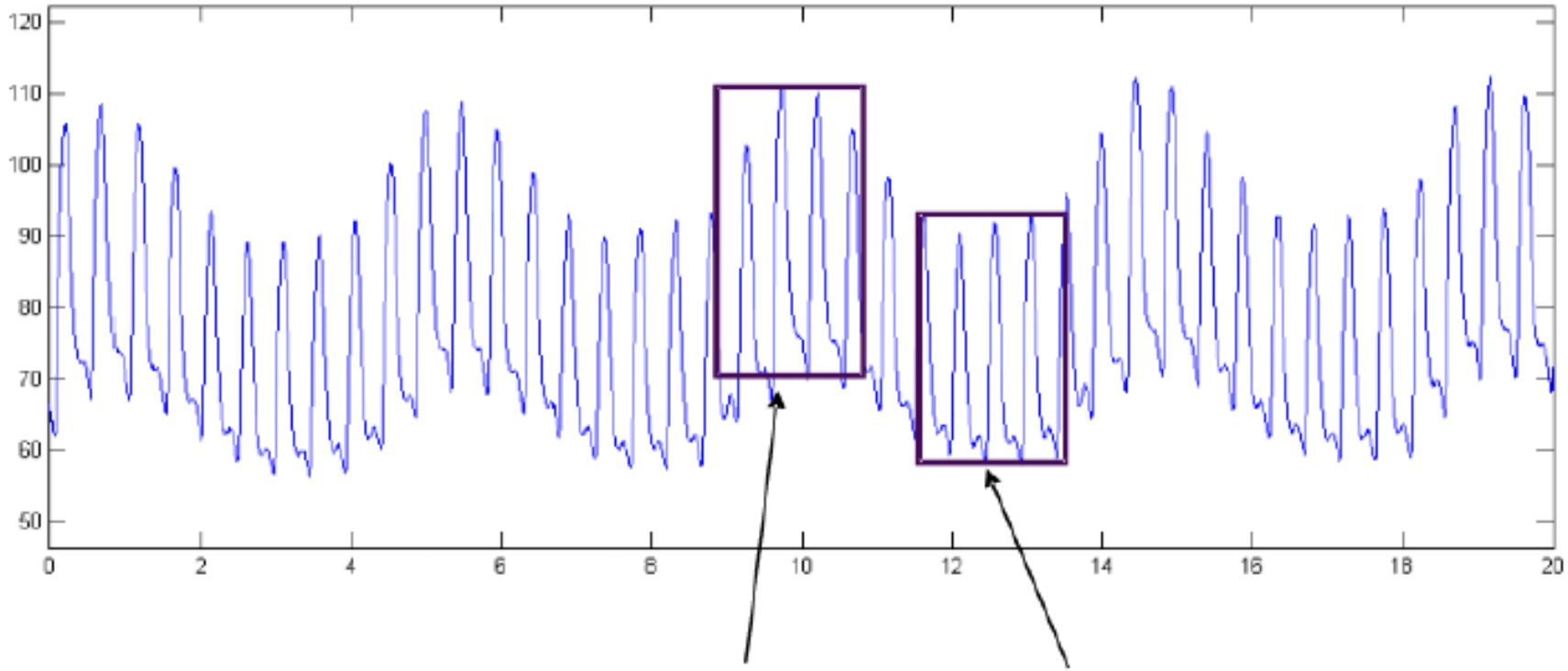
SVV = Stroke Volume Variation



- The variation in stroke volume over the respiratory cycle
- Correlates directly with the response of the cardiac ejection to preload increase (volume responsiveness)

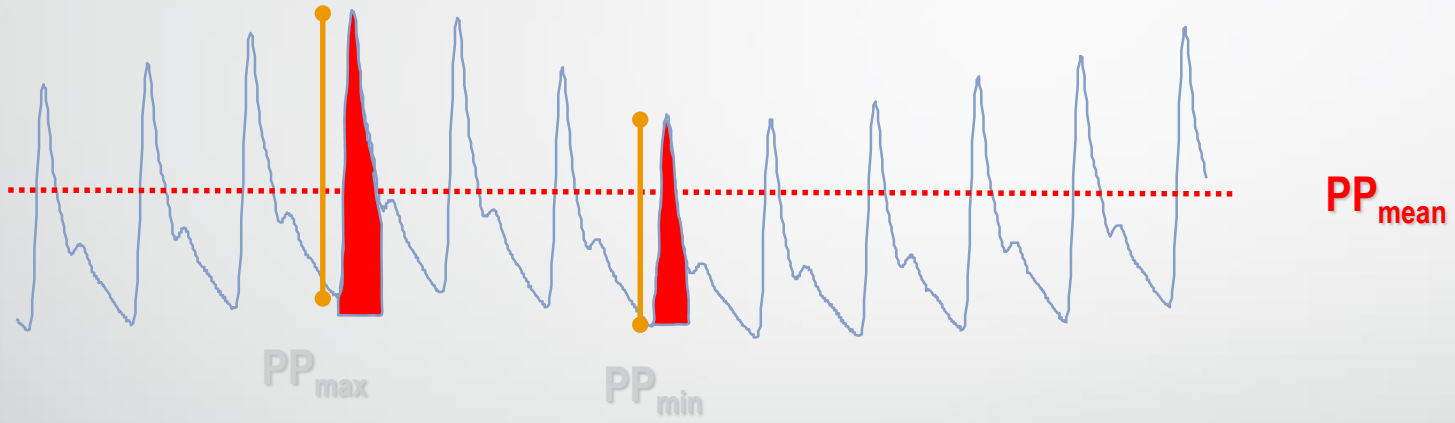
FloTrac Vigileo –

Stroke Volume Variation

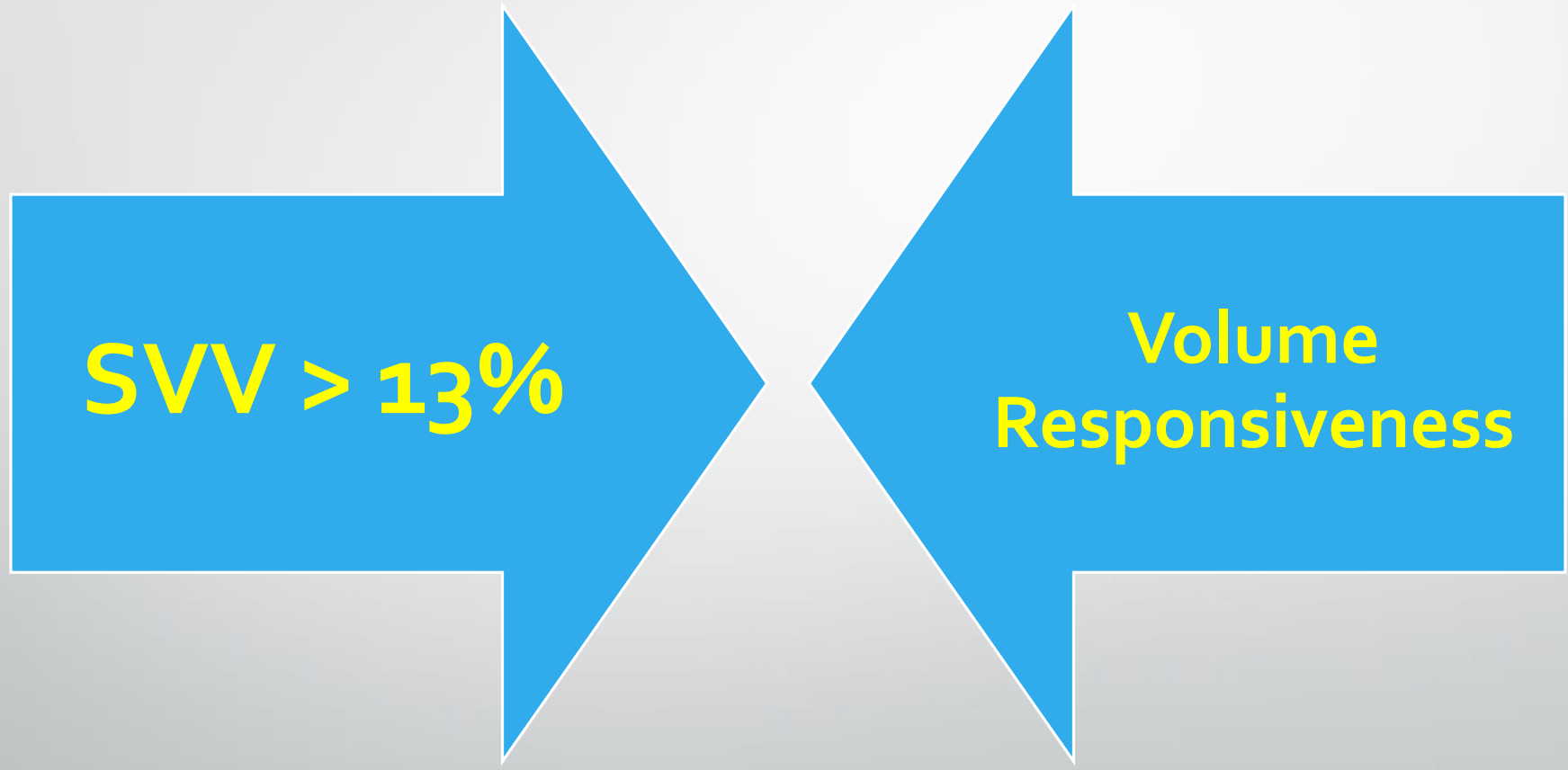


$$SVV = \frac{SV_{max} - SV_{min}}{SV_{mean}}$$

PPV = Pulse Pressure Variation



- The variation in pulse pressure amplitude over the respiration cycle
- Correlates equally well as SVV for volume responsiveness

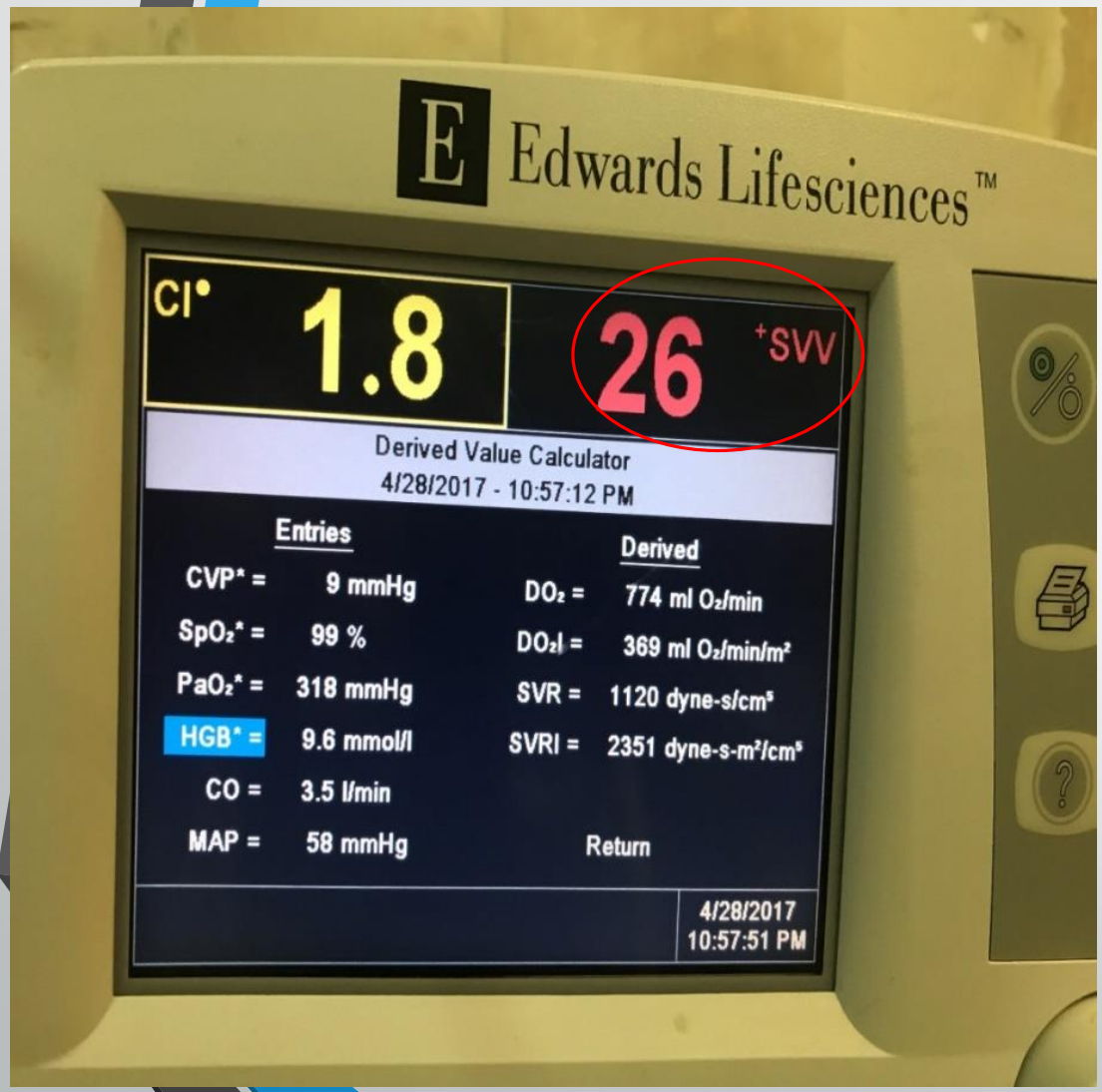

SVV > 13%
Volume Responsiveness

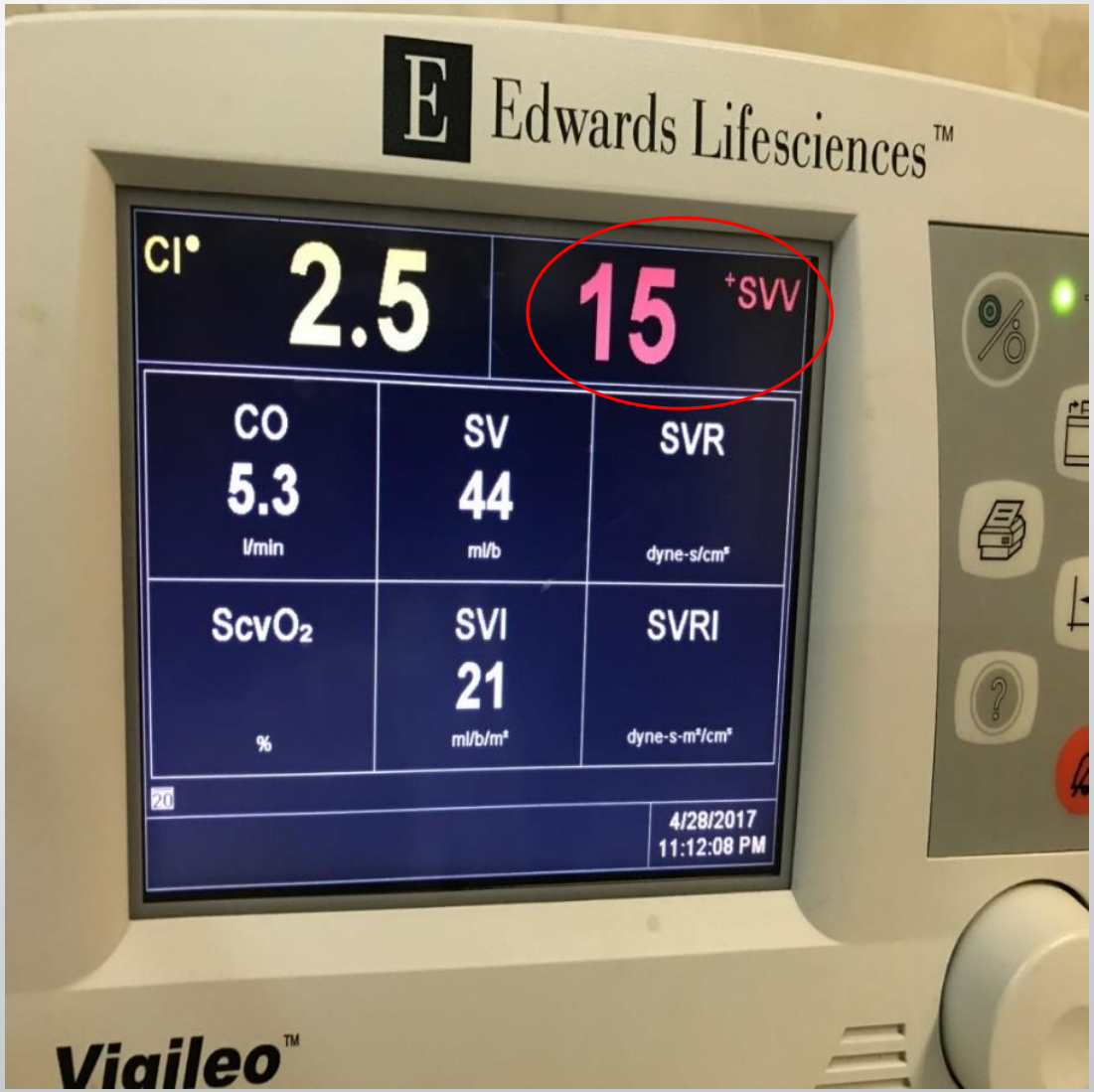
SVV Limitations

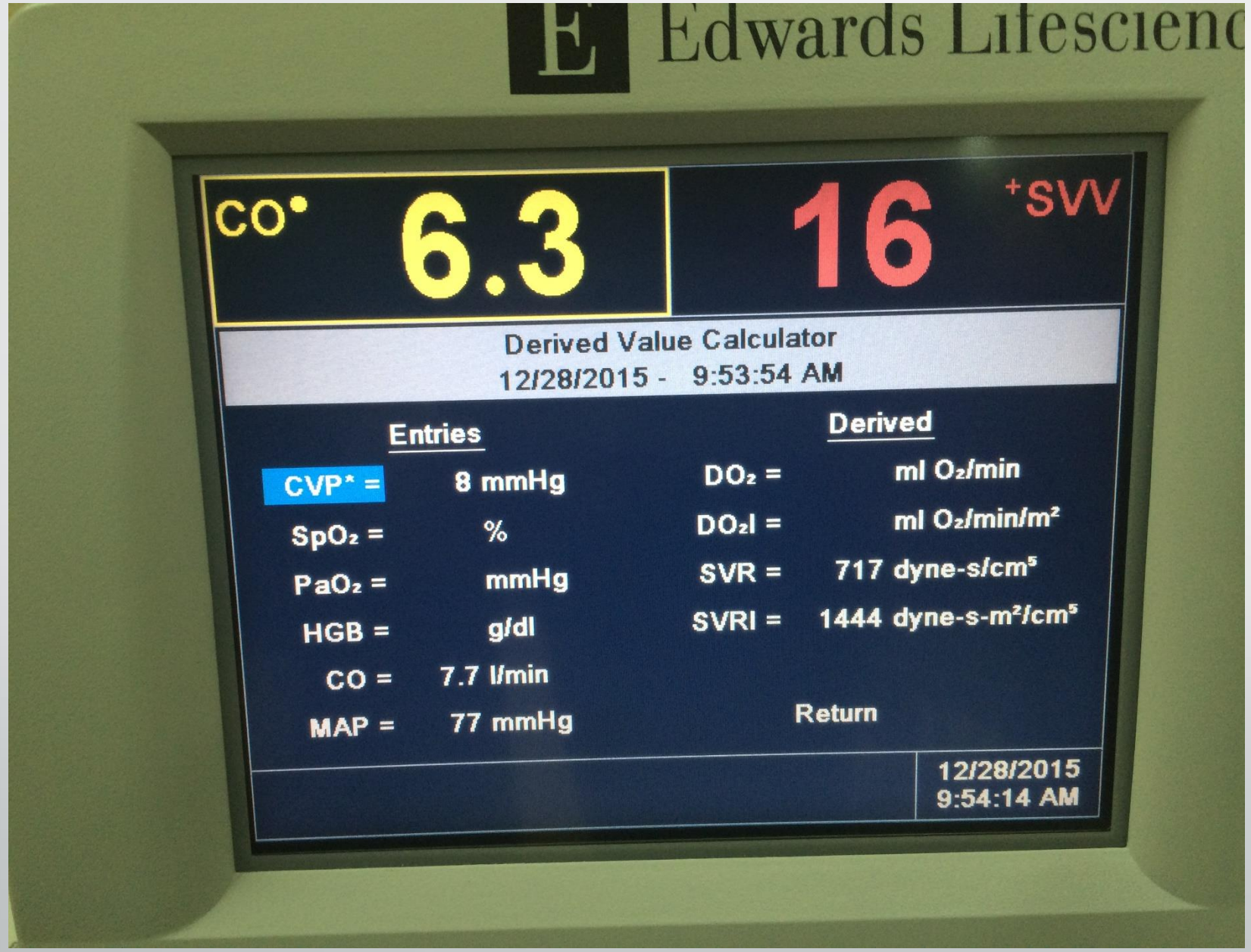
- Spontaneous Ventilation
- Arrhythmia
- Tachycardia(HR > 150/min)
- Open Chest
- Raised intra abdominal pressure
- Weight<40 kg

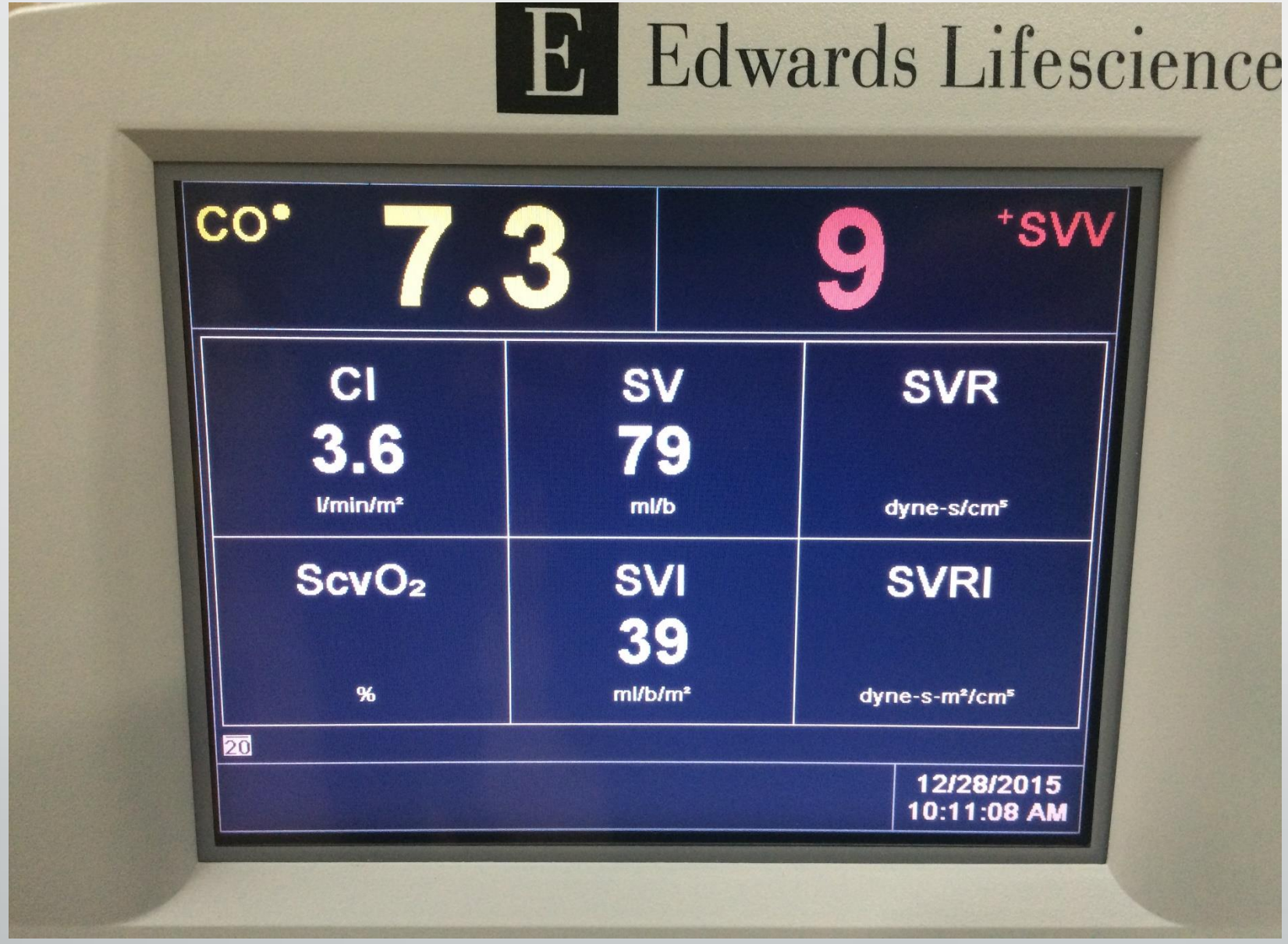
SVV and PPV:

- Good predictors of a potential increase in CO due to volume administration


Edwards Lifesciences™
CI
1.8
26
SVV
Derived Value Calculator
4/28/2017 - 10:57:12 PM
Entries
Derived
CVP* = 9 mmHg
DO2 = 774 ml O2/min
SpO2* = 99 %
DO2I = 369 ml O2/min/m2
PaO2* = 318 mmHg
SVR = 1120 dyne-s/cm5
HGB* = 9.6 mmol/l
SVRI = 2351 dyne-s-m2/cm5
CO = 3.5 l/min
MAP = 58 mmHg
Return
4/28/2017
10:57:51 PM


Edwards Lifesciences™
CI
2.5
15
SVV
CO
5.3
l/min
SV
44
ml/b
SVR
dyne-s/cm5
ScvO2
%
SVI
21
ml/b/m2
SVRI
dyne-s-m2/cm5
4/28/2017
11:12:08 PM
Vigileo™


Edwards Lifescienc
CO•
6.3
16
+SVV
Derived Value Calculator
12/28/2015 - 9:53:54 AM
Entries
Derived
CVP* =
8 mmHg
DO₂ =
ml O₂/min
SpO₂ =
%
DO₂I =
ml O₂/min/m²
PaO₂ =
mmHg
SVR =
717 dyne-s/cm⁵
HGB =
g/dl
SVRI =
1444 dyne-s-m²/cm⁵
CO =
7.7 l/min
MAP =
77 mmHg
Return
12/28/2015
9:54:14 AM


Edwards Lifescience
CO
7.3
9
+SVV
CI
3.6
l/min/m²
SV
79
ml/b
SVR
dyne-s/cm⁵
ScvO₂
%
SVI
39
ml/b/m²
SVRI
dyne-s-m²/cm⁵
20
12/28/2015
10:11:08 AM


MAP & HR (mmHg & BPM)
MAP & HR (2 mins)
30m
20m
10m
0m
nCO (L/min)
nCO (2 mins)
BP - ABP (Ch 1)
SVV (10 mins)
Delta SV
Hemodynamic
Sys
Mean
Dia
74
53
42
HR
102
bpm
nCO + nSVR
nCO
10.6
nSVR
360
Blood Pressure
Preload Response
SVV
13 %
HRV
3 %
NIBP


Rapid
NIBP
19:19
MAP & HR (mmHg & BPM)
200
150
100
50
0
90m
60m
30m
0m
MAP & HR (2 mins)
nCO (L/min)
15
10
5
0
nCO (2 mins)
BP - ABP (Ch 1)
300
150
0
6
4
2
0
PPV (10 mins)
40%
30%
20%
10%
0%
Delta PP
20%
-20%
-40%
Hemodynamic
Sys
Mean
Dia
113
90
74
HR
107
bpm
nCO + nSVR
nCO
8.9
nSVR
726
Blood Pressure
P
0
Preload Response
PPV
12 %
HRV
1 %

- 'Pleth Variability Index' (PVI)

- **IVC distensibility index**
  - ΔIVC ≥12-18% : Responsiveness
- SVC collapsibility
  - ΔSVC >36% : Volume Responsiveness

Take home message

- Both Hypo@Hyper volemia can be harmful
- Static techniques are not enough to good volume management
- ITBV@GEDV are accurate in volume assessment
- Dynamic parameters as SVV@PPV are used for volume responsiveness