ESICT

The Egyptian Society of Intensive Care and Trauma

الجمعية المصرية للرعاية المركزة والإصابات

14-15 December 2023

Helnan Landmark Hotel
New Cairo

11TH International Conference
of the Egyptian Society of Intensive Care and Trauma

ESICT 2023
Egyptian Society of Intensive Care and Trauma

Hemodynamic Monitoring Workshop

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Semi Invasive Hemodynamic Monitoring

Value Based Decision Making

The importance of COP monitoring is that COP determines O_2 delivery and organ perfusion.

Do_2=COP x HB x O_2 saturation

Reduced COP or low COP syndrome

↓

O_2 delivery demand imbalance

↓

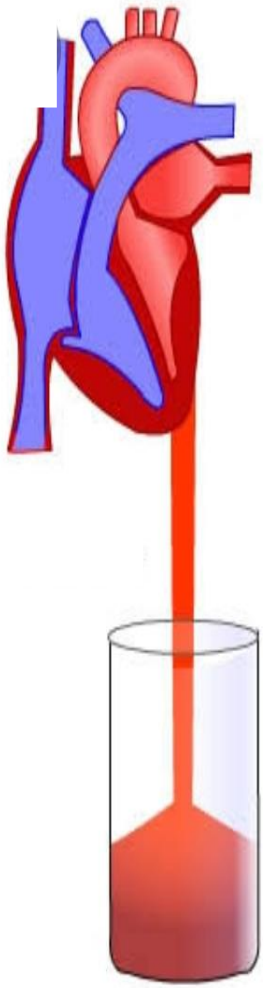
Decreased sVo2

↓

Poor tissue perfusion

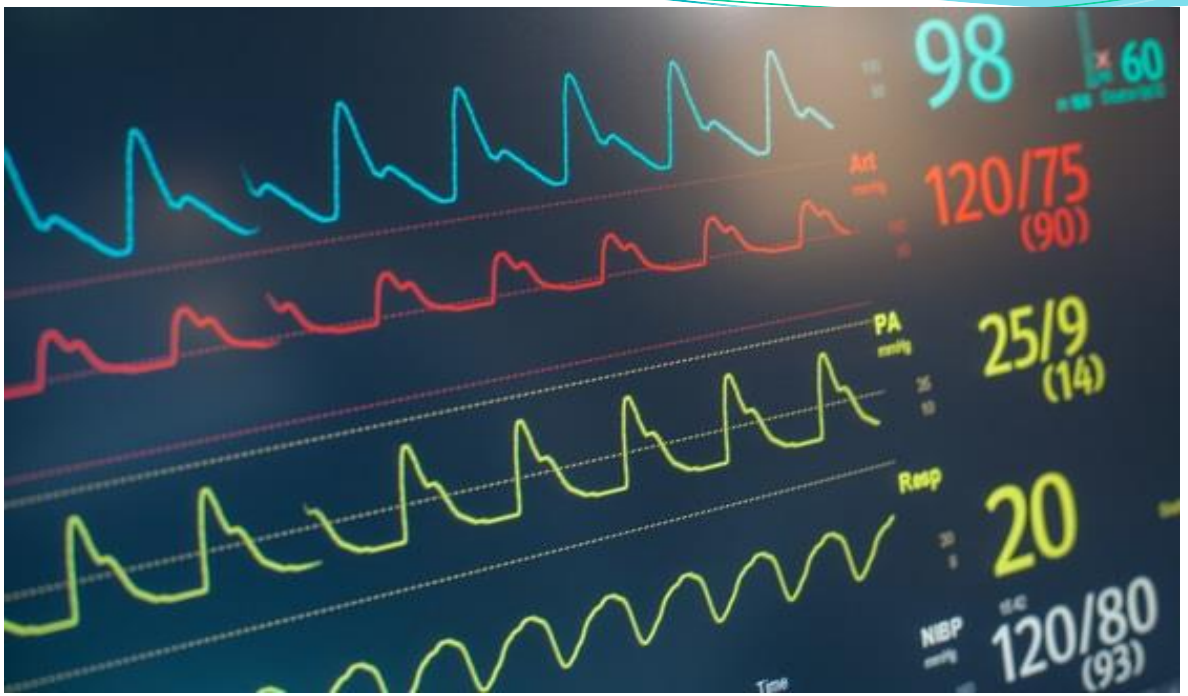
↓

Lactic acidosis



Purpose of hemodynamic monitoring

- **Establish baseline values and evaluate trends to determine degree and presence of dysfunction.**
- **Implement and guide interventions early to prevent problems.**



Accurate, continous and advanced hemodynamic monitoring helps physicians understand complex conditions of critically ill patients in intensive care units and during high-risk surgeries and helps to optimize their hemodynamic condition, so improving outcome.

To make the best use of any monitoring modality, the potential benefits to be gained from the information must outweigh the potential complications.

Comparison of different cardiac output modalities

Device	Cost	Invasiveness	Accuracy	Ease of use	Reproducibility
PAC	£££	Highly	+++	Difficult	+++
LiDCO™ (dilution)	££	Moderately	++	Moderate	+++
Doppler	£	Moderately	++	Moderate	+
Waveform analysis					
• Vigileo™	££	Minimally	++	Very easy	+++
• LiDCO rapide™	££	Minimally	++	Very easy	+++
• PiCCO™	££	Moderately	++	Easy	+++
Finger cuff	££	Non-invasive	+	Very easy	+++
Echocardiography	£££	Minimally	+++	Difficult	++
Bio-impedance	££	Non-invasive	+	Very easy	+++
Ultrasound velocity dilution	£££	Highly	+++	Difficult	+++
Magnetic resonance	££££	Minimally	+++	Difficult	+++

75-year-old patient in the intensive care unit (ICU) is extubated after recovering from acute respiratory distress syndrome (ARDS). He has a history of previous myocardial infarction, congestive heart failure, and pneumonia. He has an A-line, pulmonary artery (PA) catheter and is receiving oxygen by nasal cannula. Which of the following techniques is LEAST accurate for assessing an intravascular fluid challenge?

A. Central venous pressure (CVP)

B. PA occlusion pressure

C. Transesophageal echocardiography (TEE)

D. Measurement of pulse pressure variation (PPV)

- An intravascular fluid challenge is frequently used to increase preload and cardiac output.

- A PA catheter is often placed to measure the CVP, PA pressure, and wedge pressure, and can determine the cardiac output (usually by thermodilution).

- The CVP measures the filling pressure for the right ventricle, and the PA occlusion or wedge pressure measures the filling pressure for the left ventricle.

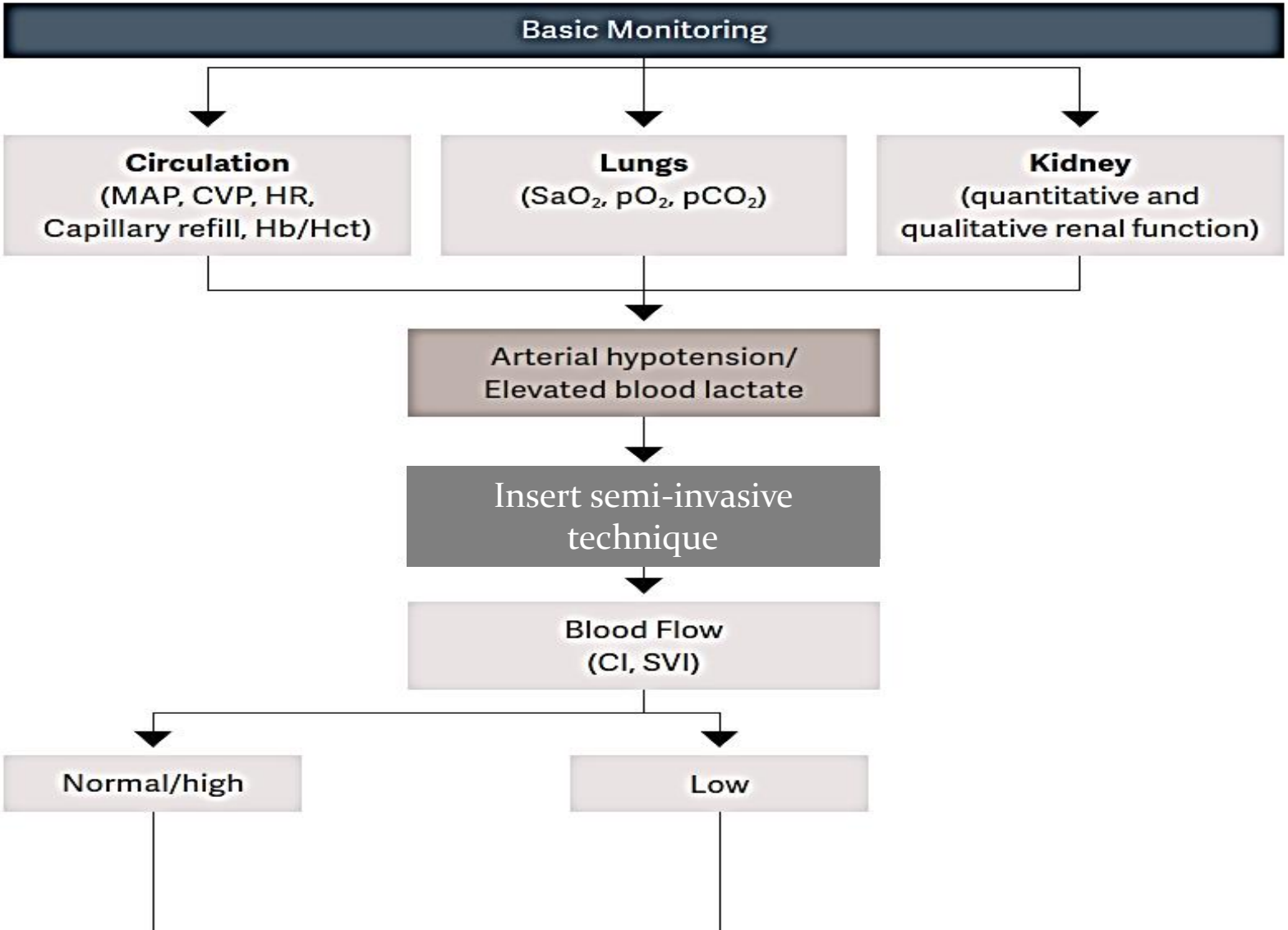
- TEE can be used to look at the size of the ventricular chambers and how well they contract (e.g., ejection fraction).

- When a patient is receiving positive pressure ventilation, measurement of PPV or systolic pressure variation (SPV) can be done.

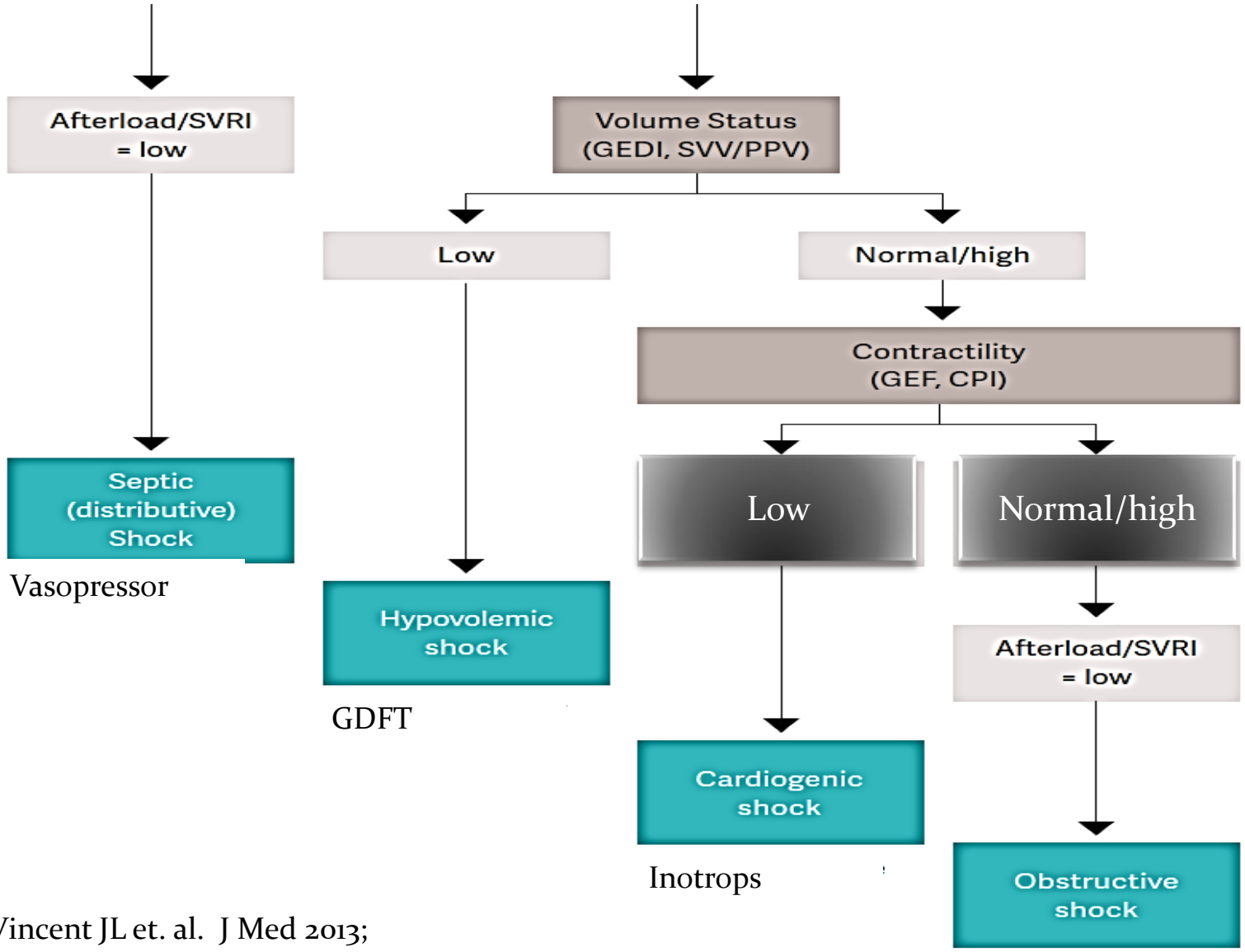
- This situation is different, the patient is mechanically ventilated post CABG surgery. So we can relay on PPV readings.

Goal directed hemodynamic therapy

Example: Differentiation tree of shock



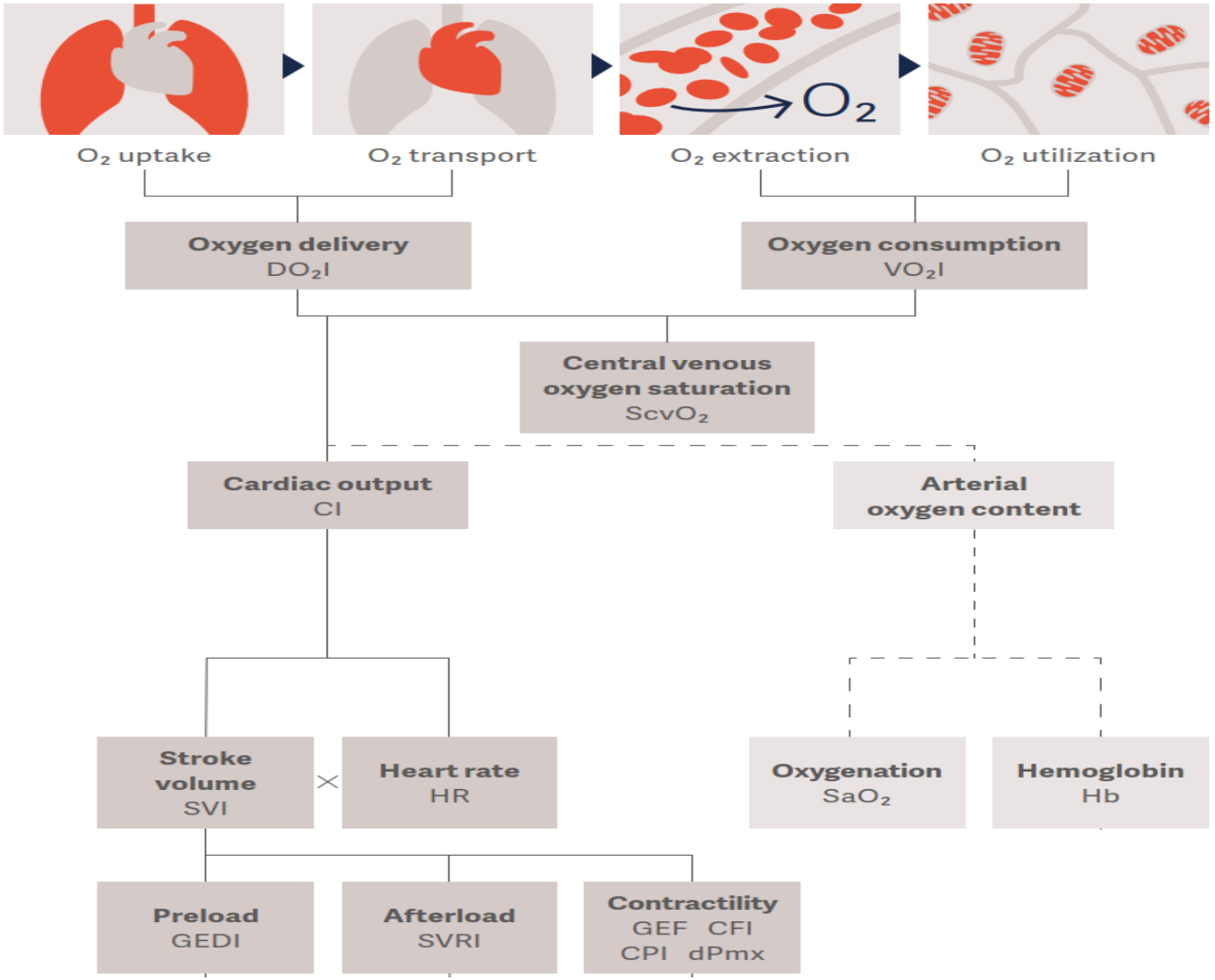
Cont....



Based on Vincent JL et. al. J Med 2013; 369:1726-1734.

GDFT: Goal directed fluid thearpy

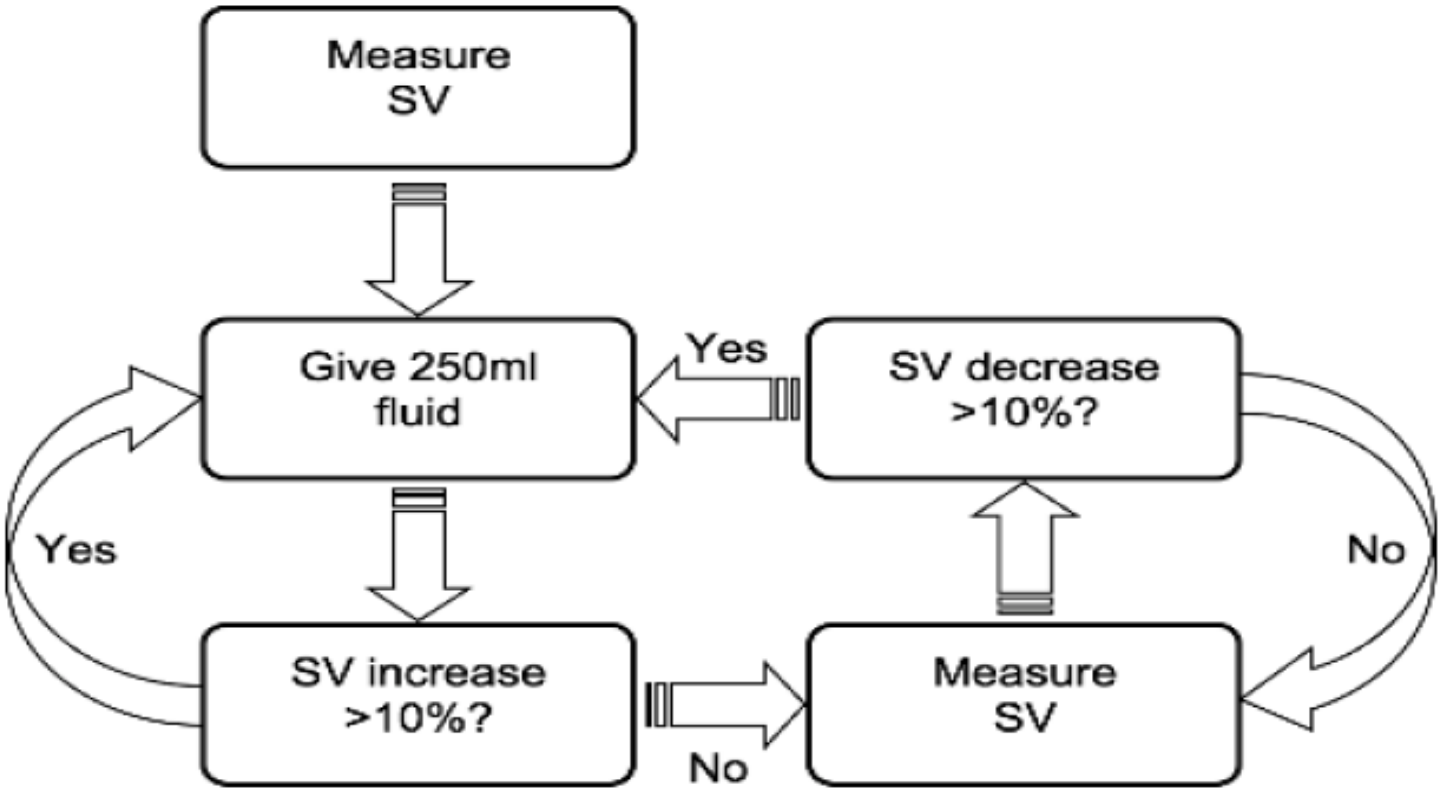
Basic Physiology
Hemodynamic parameters



Goal-direct therapy (GDT)

- **Goal-direct therapy (GDT) aims to assure tissue perfusion, by optimizing doses and timing of fluids, inotropes, and vasopressors, through monitoring of cardiac output and other basic hemodynamic parameters. Several meta-analysis confirm that GDT can reduce postoperative complications.**

- **The term goal directed fluid therapy simply implies that fluid is administered in order to achieve a measurable and repeatable target.**



Significance of perioperative goal-directed hemodynamic approach in preventing postoperative complications in patients after cardiac surgery: a meta-analysis and systematic review

Peng Li, Li-ping Qu, Dong Qi, Bo Shen, Yi-mei Wang, Jia-rui Xu, Wu-hua Jiang, Hao Zhang, Xiao-qiang Ding & Jie Teng

Individually Optimized Hemodynamic Therapy Reduces Complications and Length of Stay in the Intensive Care Unit

A Prospective, Randomized Controlled Trial

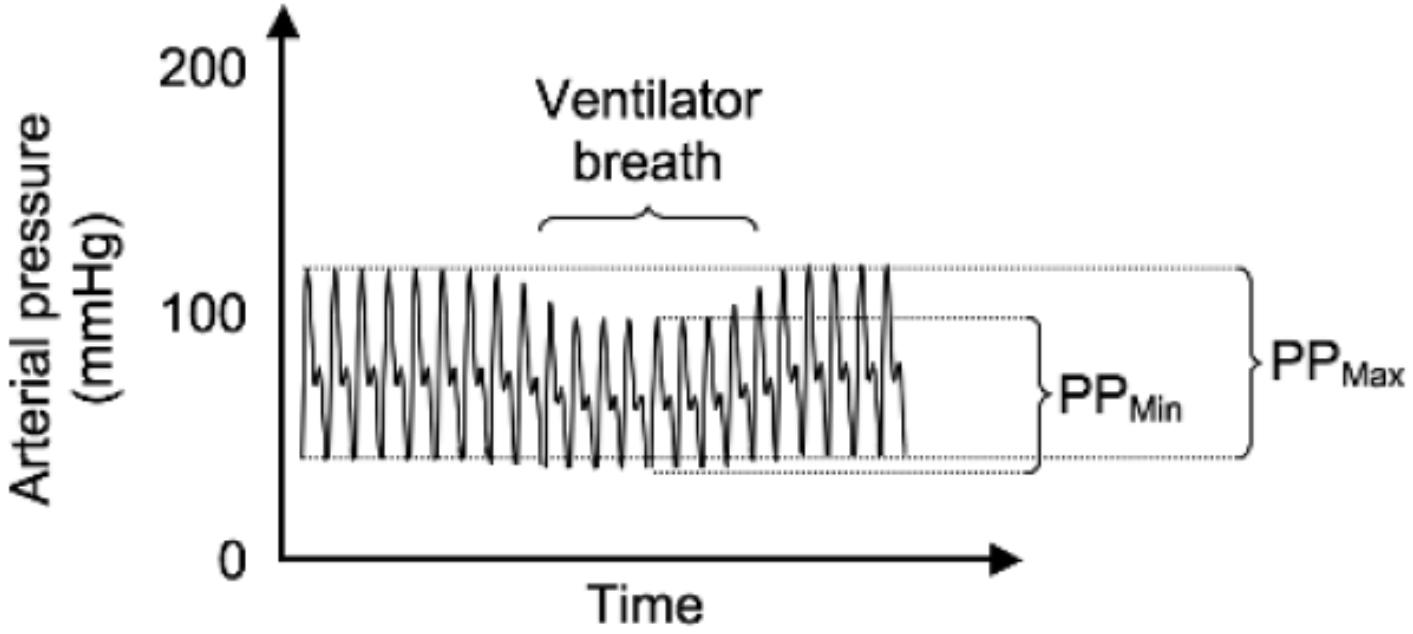
Matthias S. Goepfert, M.D.,* Hans Peter Richter, M.D.,† Christine zu Eulenburg, Sc.D.,‡ Janna Gruetzmacher, M.D.,§ Erik Rafflenbeul, M.D.,§ Katharina Roeher, M.D.,* Alexandra von Sandersleben, M.D.,* Stefan Diedrichs, M.D.,† Herrmann Reichenspurner, M.D., Ph.D.,‖ Alwin E. Goetz, M.D., Ph.D.,# Daniel A. Reuter, M.D., Ph.D.**

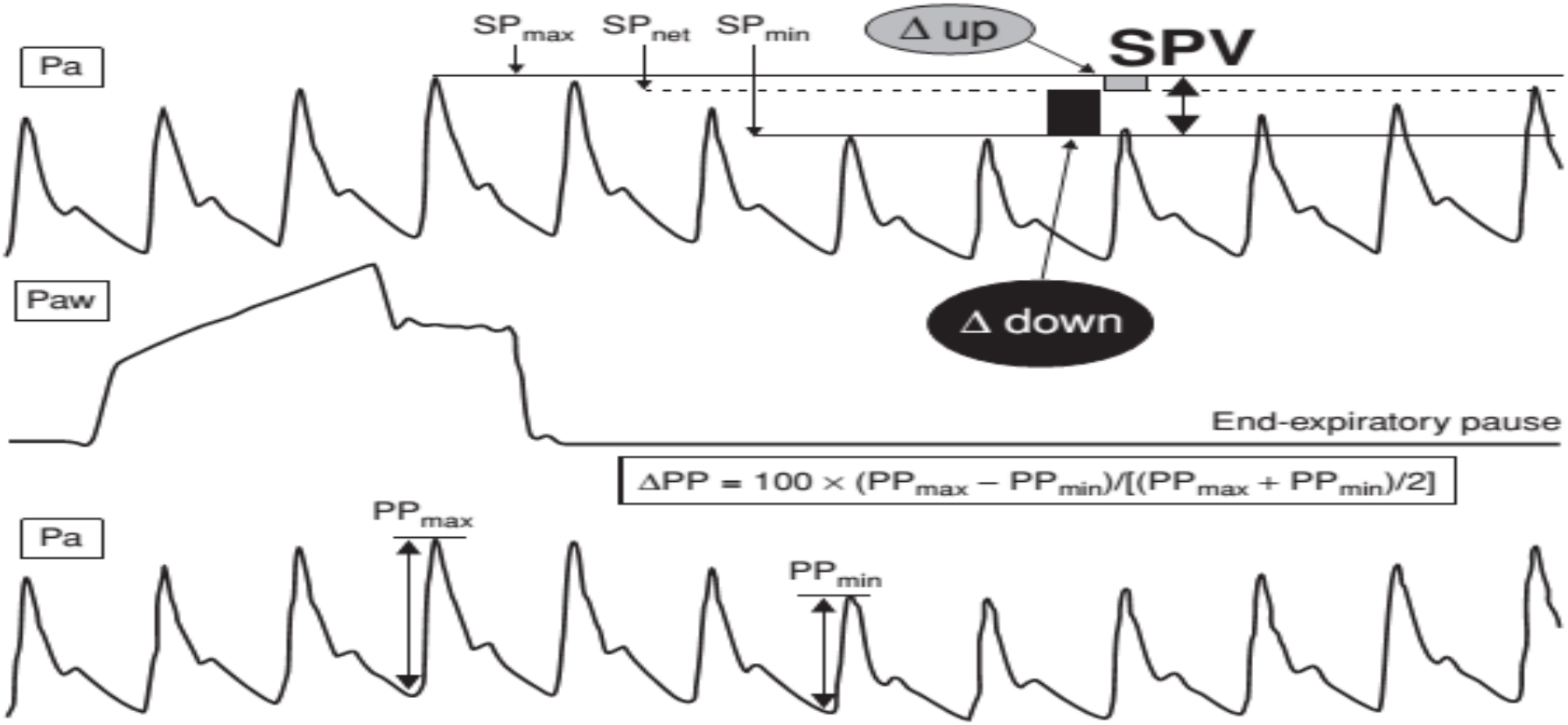
Systolic pressure variation (SPV) and pulse pressure variation (PPV)

- **Arterial waveform analysis and, in particular, the influence of positive pressure ventilation on the cyclic variation of the arterial pressure has been studied.**
- **Typically, increased variation in arterial pressure is seen in hypovolemic patients, and its response to fluid administration also has been studied.**

Pulse pressure variation

- **The change in magnitude of the SBP-DBP difference of the arterial pressure waveform with concomitant positive pressure ventilation. Used as a marker of fluid responsiveness. (PPV, %).**





Analytic description of respiratory changes in arterial pressure during mechanical ventilation. The systolic pressure and the pulse pressure (systolic minus diastolic pressure) are maximum (Spmax and PPmax, respectively) during inspiration and minimum (SPmin and PPmin, respectively) a few heartbeats later – i.e. during the expiratory period. The systolic pressure variation (SPV) is the difference between SP max and SPmin. The assessment of a reference systolic pressure (SPref) during an end-expiratory pause allows the discrimination between the inspiratory increase (up) and the expiratory decrease (down) in systolic pressure.
Pa = arterial pressure; Paw = airway pressure.

Post operative ICU hemodynamic monitoring

- ***Goepfert et al.,*** **concluded that guiding therapy (GDHT) in patients under going cardiac bypass surgery by an algorithm based on GEDVI (global end diastolic volume index) to asses preload using PiCCO system leads to a shortened and reduced need for vasopressors and inotropes.**

- **A study by *Kapoor et al.,* specifically evaluated GDT in high risk cardiac surgical patients and reported significant reduction in the duration of inotrope infusion reduced ICU and hospital length of stay.**

Perioperative COP monitoring modalities

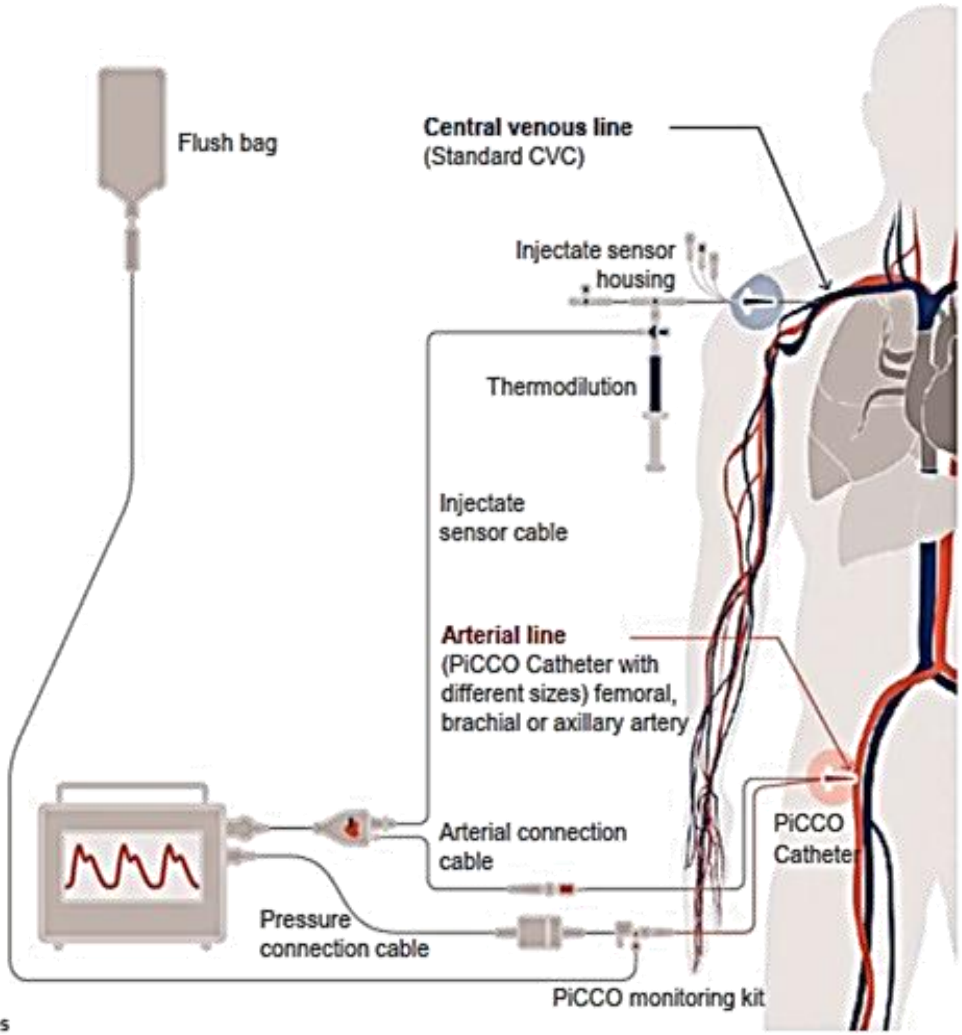
Stroke Volume and Pulse Pressure Variation for Prediction of Fluid Responsiveness in Patients Undergoing Off-Pump Coronary Artery Bypass Grafting*

Christoph K. Hofer, MD; Stefan M. Müller, MD; Lukas Furrer, MD; Richard Klaghofer, PhD; Michele Genoni, MD; and Andreas Zollinger, MD

- **Conclusion: In contrast to standard preload indexes, SVV and PPV, comparably, showed a good performance in predicting fluid responsiveness in patients before off-pump coronary artery bypass grafting.**

Pulse contour analysis for cardiac output (PiCCO)

PiCCO set-up with Pulsioflex

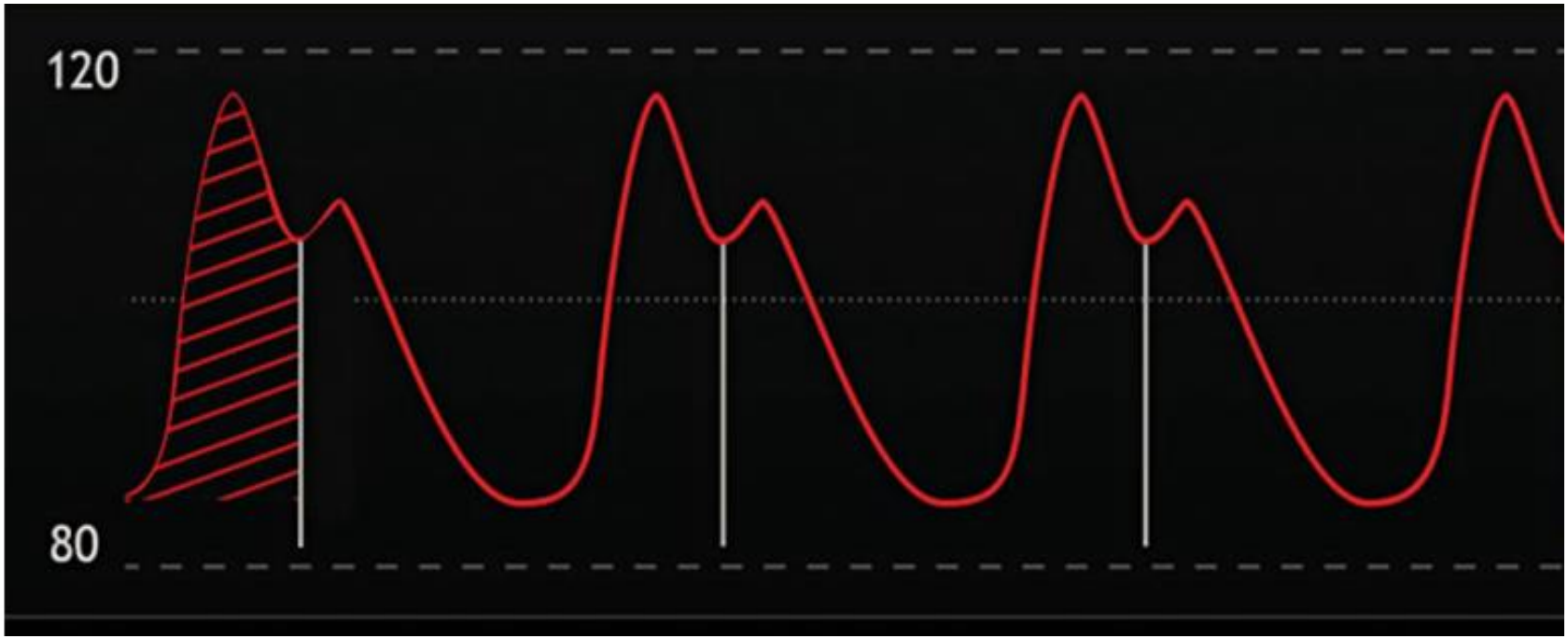


PulsioFlex Monitor

PiCCO Technology physical principles

A- Arterial pulse contour analysis

- **The pulse contour analysis provides continuous information, while transpulmonary thermodilution provides intermittent measurements. Transpulmonary thermodilution is used to calibrate the continuous pulse contour parameters.**



- **Arterial pulse contour analysis. The shaded area below the systolic part of the pressure curve is proportional to the stroke volume.**

B- Transpulmonary thermodilution

- **For the transpulmonary thermodilution measurement, a defined bolus (e. g. 15 ml cold normal saline) is injected via a central venous catheter.**

- **The cold bolus passes through the right heart, the lungs, the left heart and is detected by the PiCCO catheter, commonly placed in the femoral artery.**

- **This procedure should be repeated around three times in under 10 minutes to ensure an accurate average is used to calibrate the device and to calculate the thermodilution parameters. These thermodilution parameters should be checked whenever there is a significant change in the patient's condition or therapy. It is recommended to calibrate the system at least 3 times per day.**

PiCCO thermodilution measurements check list

1 – Check arterial pressure signal, possibly flush pressure line

– Check correct zeroing procedure

2 – Prepare cold saline solution (3x15ml minimum)

– Start thermodilution at the device

3 – Observe screen messages and when recommended

– Inject bolus rapidly and steadily into the distal lumen of the CVC

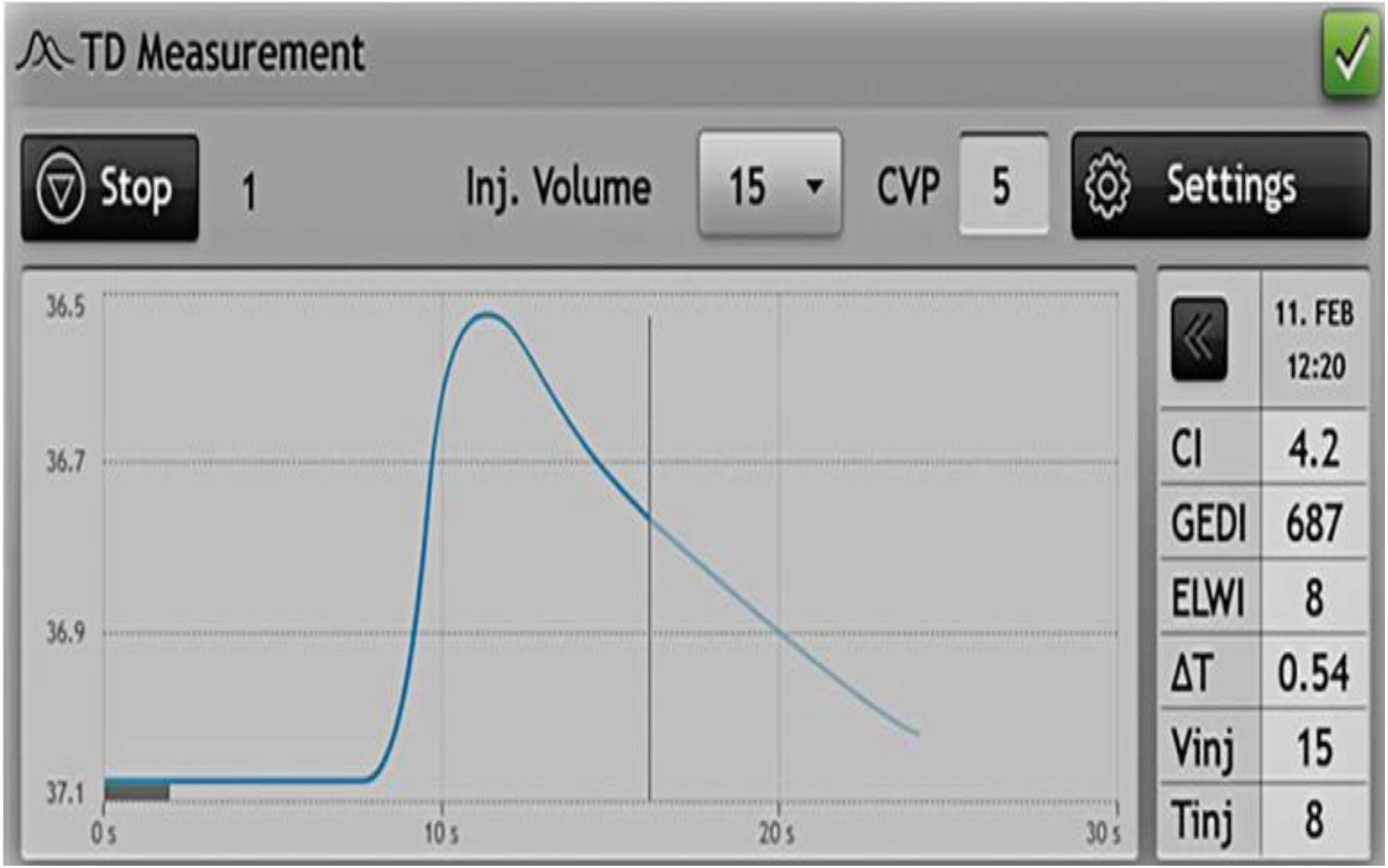
4 – Observe the thermodilution curve on the screen:

– Check that $\Delta T \geq 0.2°$, if not use more indicator (colder or more volume)

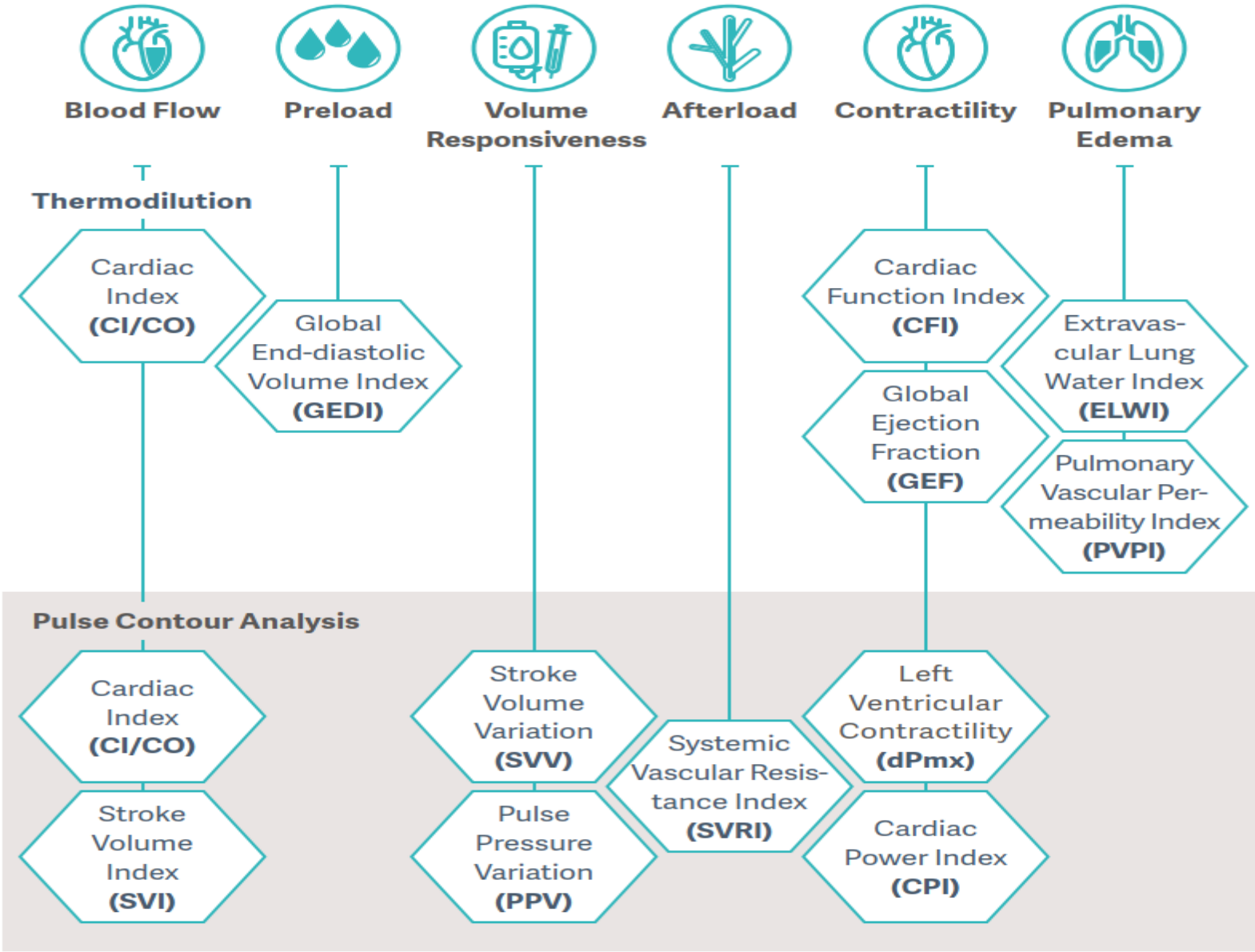
5– Repeat STEP 2 to 4 until 3 satisfying measurements are obtained and confirm with calibrate (values deviations < 15% from the mean)

6– Enter the CVP value (to calculate SVRI)

Transpulmonary thermodilution measurement

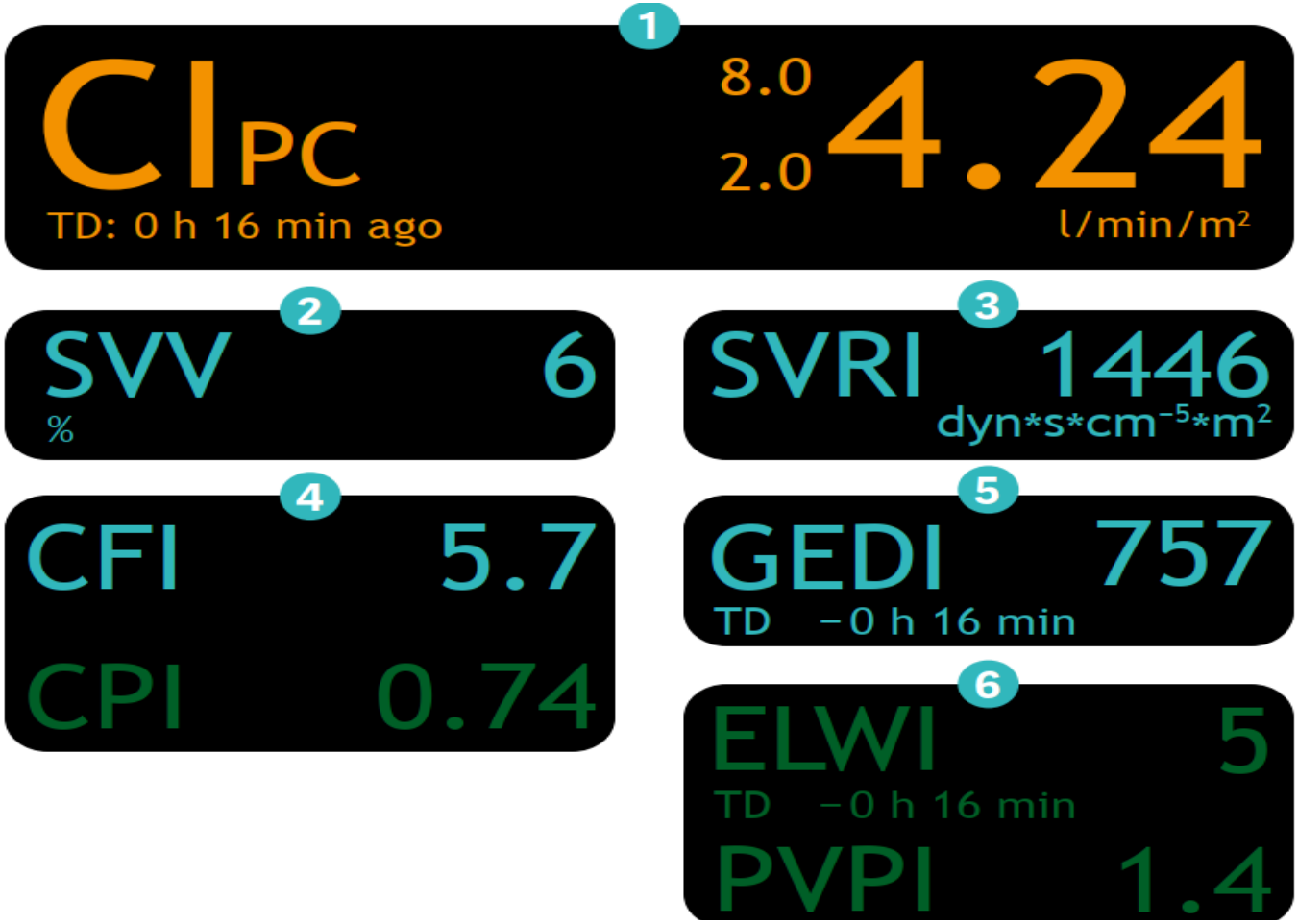


PiCCO Parameters



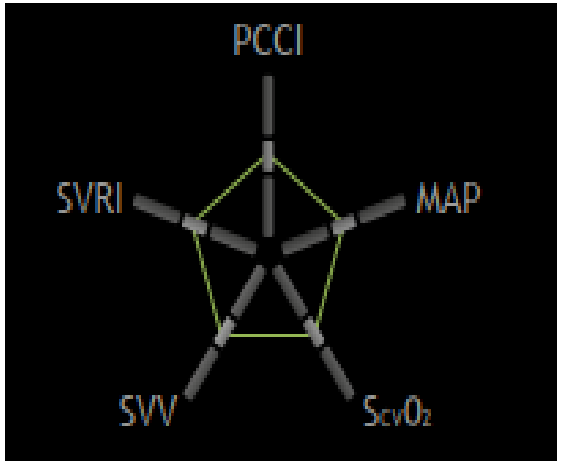
Graphical data interpretation

General physiological assignment of PiCCO parameters

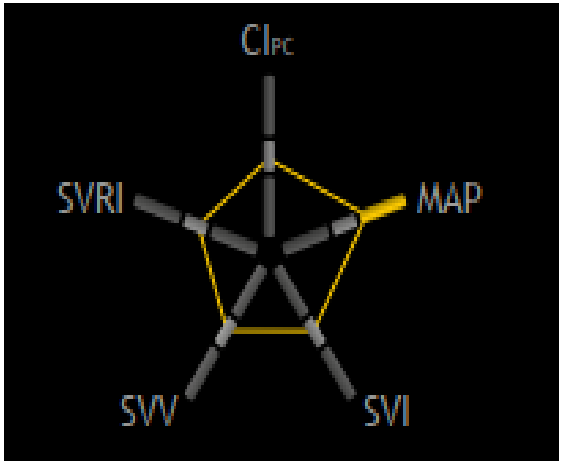


Spider Vision

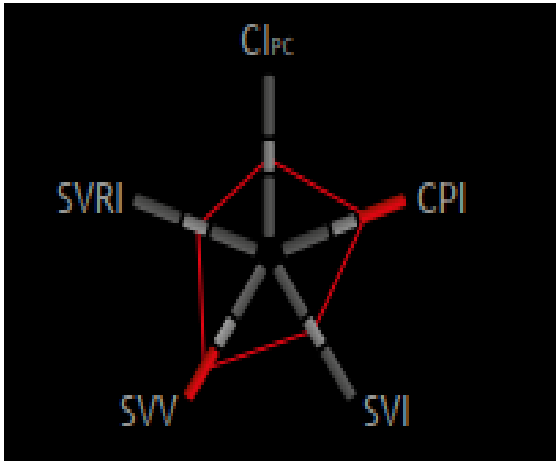
- **Traffic light system for simple risk evaluation**
- **Configurable detection of dynamic changes**



Green: all parameters in normal range



Yellow: one parameter outside the normal range



Red: more than one parameter outside the normal range

Variable parameters of NICCI, ProAQT and PiCCO



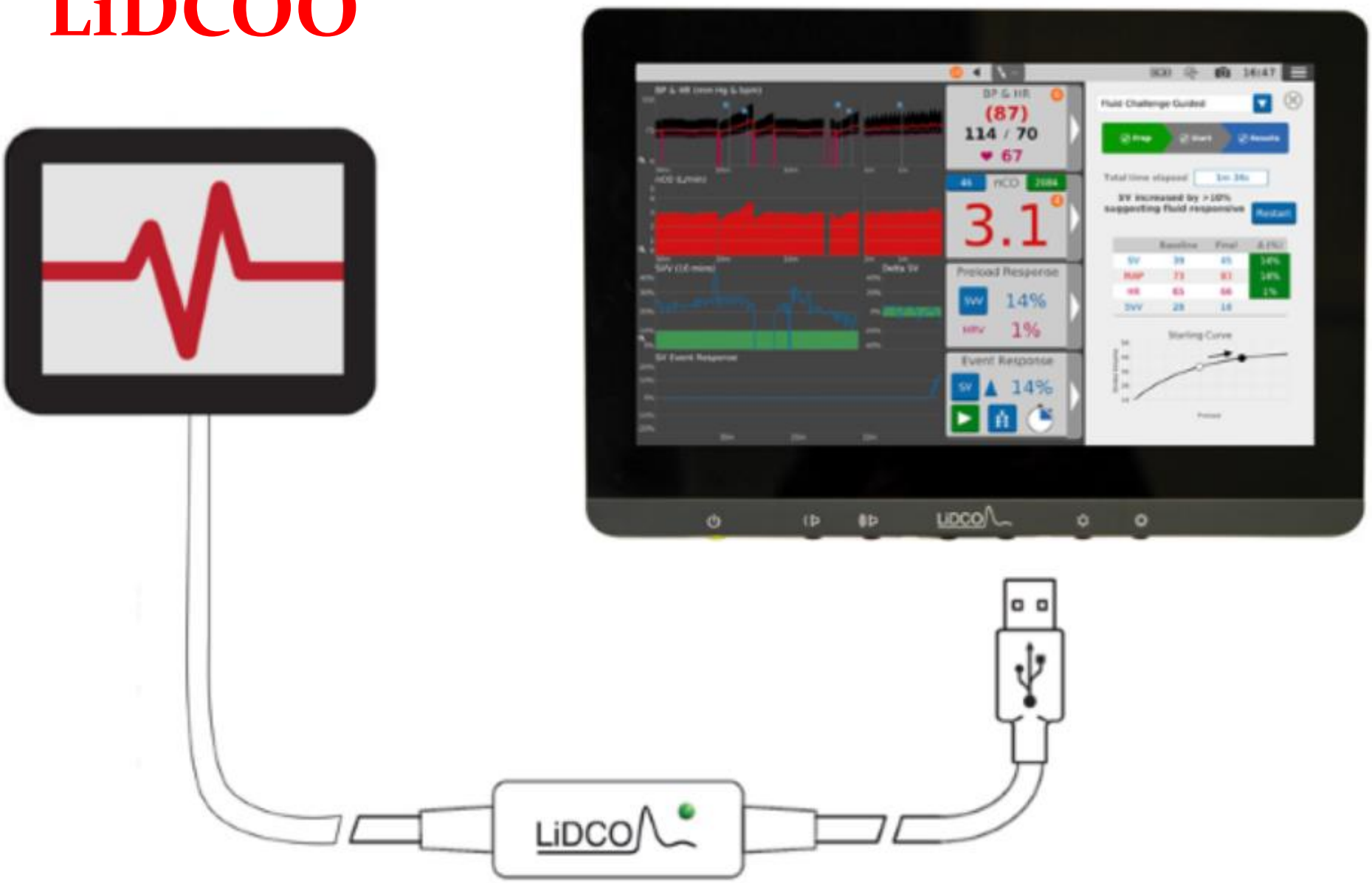
	NICCI	ProAQT	PiCCO
Invasiveness	Noninvasive	Minimally invasive arterial line	Less invasive arterial catheter
Pulse contour analysis (continuous)			
Chronotropy	PR	HR	HR
Blood Pressure	AP_{sys}, AP_{dia}, MAP	AP_{sys}, AP_{dia}, MAP	AP_{sys}, AP_{dia}, MAP
Flow	$CI_{Trend/Cal}$**, SVI	$CI_{Trend/Cal}$**, SVI	CI_{PC}*, SVI
Contractility	dPmx, CPI	dPmx, CPI	dPmx, CPI
Afterload	SVRI	SVRI	SVRI
Volume responsiveness	SVV, PPV	SVV, PPV	SVV, PPV
Thermodilution (discontinuous)			
Flow			CI_{TD}***
Preload			GEDI, ITBI
Contractility			CFI, GEF
Pulmonary edema			ELWI, PVPI

LiDCOO

- **A bolus of isotonic lithium chloride solution is injected via a central or peripheral vein. The lithium concentration-time curve is recorded by withdrawing arterial blood past a lithium sensor attached to the arterial line.**

- **CO is calculated from the lithium dose and the area under the concentration-time curve prior to recirculation. Blood flows into the sensor assembly at a rate controlled by a peristaltic pump. A bolus dose of 0.15 to 0.30 mmol of lithium chloride is needed for an average adult.**

LiDCOO


(87)
114 / 70
67
3.1
Preload Response
14%
1%
Event Response
14%
Fluid Challenge Guided
LiDCO
LiDCO

Electrical Cardiometry EC®

- **Advanced TBI or the 5th generation.**
- **Continuous Hemodynamic Monitoring technique.**
- **Totally Non-invasive.**
- **FDA approved for Adult, Paediatrics and Neonates.**
- **Auto-Dynamic Normal ranges (based of patient's Age, Weight and Height.**

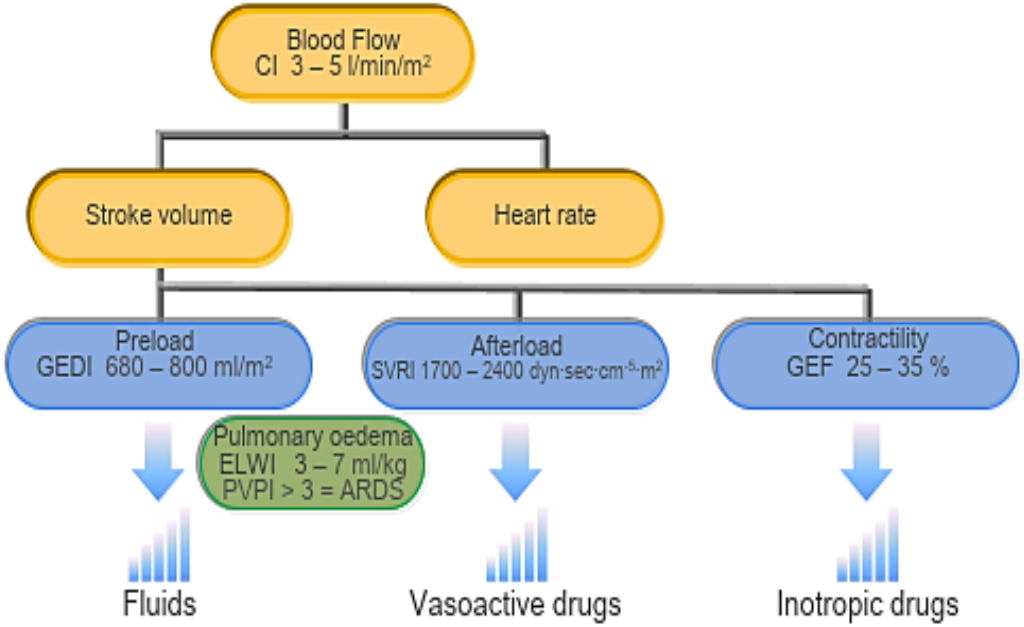
ICON™

- **Handheld EC Monitor.**
- **Internal Battery for 2 hours "EMS, Pt. Transportation".**
- **Internal Memory for data storage.**

Index of Contractility (ICON)

- **It was clinically proven that Maximum/Peak Aortic acceleration calculated during the first 20ms of aortic ejection is closely related to contractility and less affected by loading. However this index is not commonly used because it's affected by after load.**
- **High Contractility when the patient is on Inotropes is a good indicator to wean from Inotropes.**
- **Trending low ICON is a strong indicator of worsening heart Function.**
- **Trending low ICON can predict Cirrhotic Cardiomayopathy.**

Guidance for parameter interpretation

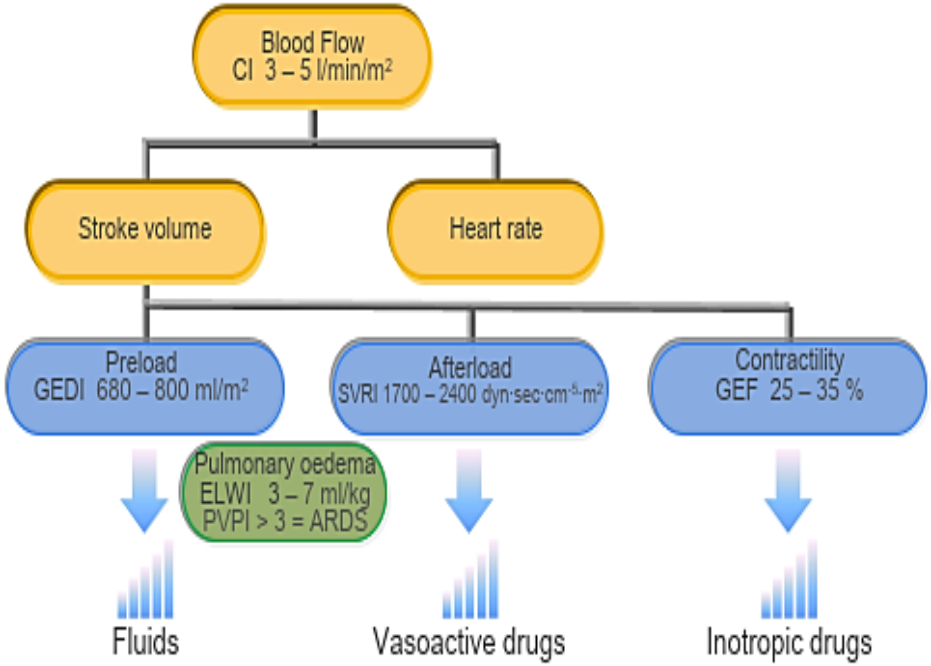


Conclusion:

Low blood flow due to low preload volume and high vascular resistance: **hypovolaemia**

Therapeutic recommendations:

- Fluid loading
- (Vasodilator)
- Repeated thermodilution measurement after therapy



Conclusion:

Low blood flow, high preload volume (fluid overload), severe pulmonary oedema, high vascular resistance, low contractility: **cardiogenic shock with cardiogenic pulmonary oedema**

Therapeutic recommendations:

- Fluid withdrawal (diuretics, CVVH with negative fluid balance)
- Inotropic drugs
- Repeated thermodilution measurement after therapy

Application restrictions

- **PiCCO catheter may not be used in patients where the placement of an indwelling arterial catheter is contraindicated as in severe peripheral vascular disease.**
- **<u>For pulse contour analysis</u>: cardiac dysrhythmia**
- **<u>For pulse pressure variation (the following must be fulfilled)</u>:**
  - **Fully controlled mechanical ventilation with a tidal volume more than 8ml/kg PBW (predicted body weight)**
  - **Sinus rhythm**
  - **Pressure curves free of artifacts**

- **For thremodilution technique:**
  - **Intracardiac shunts**
  - **Cardiac valve insufficiences**
  - **Abdominal aortic aneurysm**
- **Pulmonary perfusion disturbances as pulmonary embolism causing incorrect results concerning pulmonary edema.**

Lithium indicator dilution (LiDCOplus):

- **Accuracy decreases with: AF, IABP, AV disease, quaternary muscle relaxants, severe hyponatraemia. The system should not be used in 1st trimester pregnancy, concurrent lithium therapy, body weight <40kg.**

Hemodynamic Monitoring and Management of a Complicated Patient

- **A 68-year-old patient presents with a perforated colon secondary to diverticulitis. Vital signs are as follows: heart rate, 120 beats/min; blood pressure, 80 mm Hg/55 mm Hg; respiratory rate, 28 breaths/min; and body temperature, 38C°. The patient is scheduled for an emergency exploratory laparotomy. The patient's history includes placement of a drug-eluting stent in the left anterior descending artery 2 weeks earlier. The patient's medications include metoprolol and clopidogrel.**

- **What hemodynamic monitors should be employed?**

CONCLUSION

- **In settings of intensive care, use of minimally invasive hemodynamic monitoring devices are preferable, as real-time trends, rather than absolute values, have more value in guiding therapy.**
- **These devices dynamically assess the intravascular volume status.**
- **To predict fluid responsiveness in critically ill patients, dynamic parameters should be used preferentially to static parameters.**
- **The dynamic parameters that predict fluid responsiveness best are stroke volume variation and pulse pressure variation.**

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Thanks