ARTERIAL BP MONITORING:

Non-invasive/Invasive and Pulse Pressure Analysis

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DISCLOSURES

Nothing to disclose

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Objectives

- To determine the methods for arterial BP monitoring
- To discuss which method of BP monitoring is more appropriate in the critical care setting
- To discuss pulse pressure analysis in relation with BP monitoring

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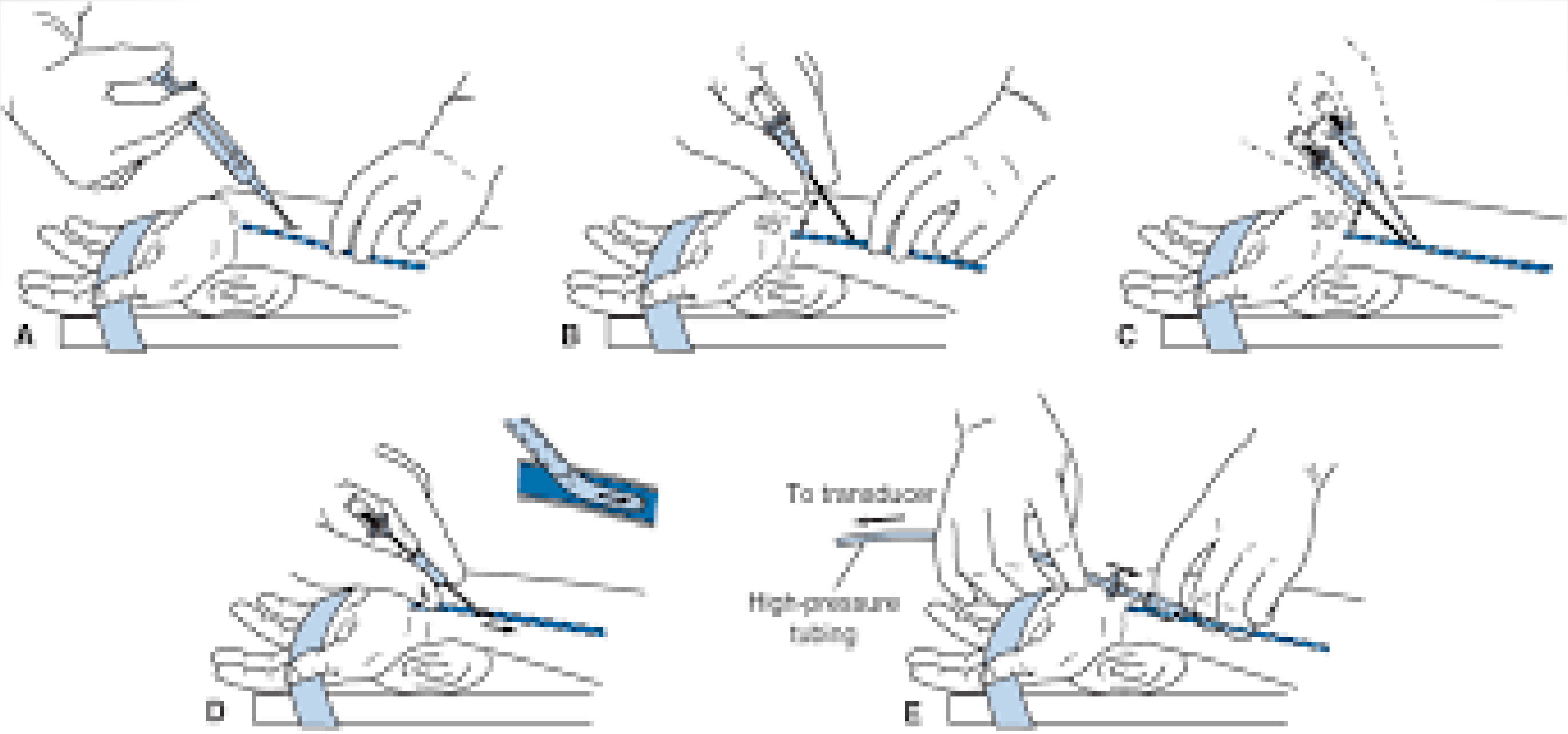
Methods of determining BP

Invasive versus Non-invasive



INVASIVE ARTERIAL BP

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Invasive Arterial BP

- INDICATIONS:
  - Monitoring continuous blood pressure especially in patients with hemodynamic instability
  - When vasoactive medications are needed and the response to such medications require continuous blood pressure monitoring.
  - For patients who require frequent blood sampling

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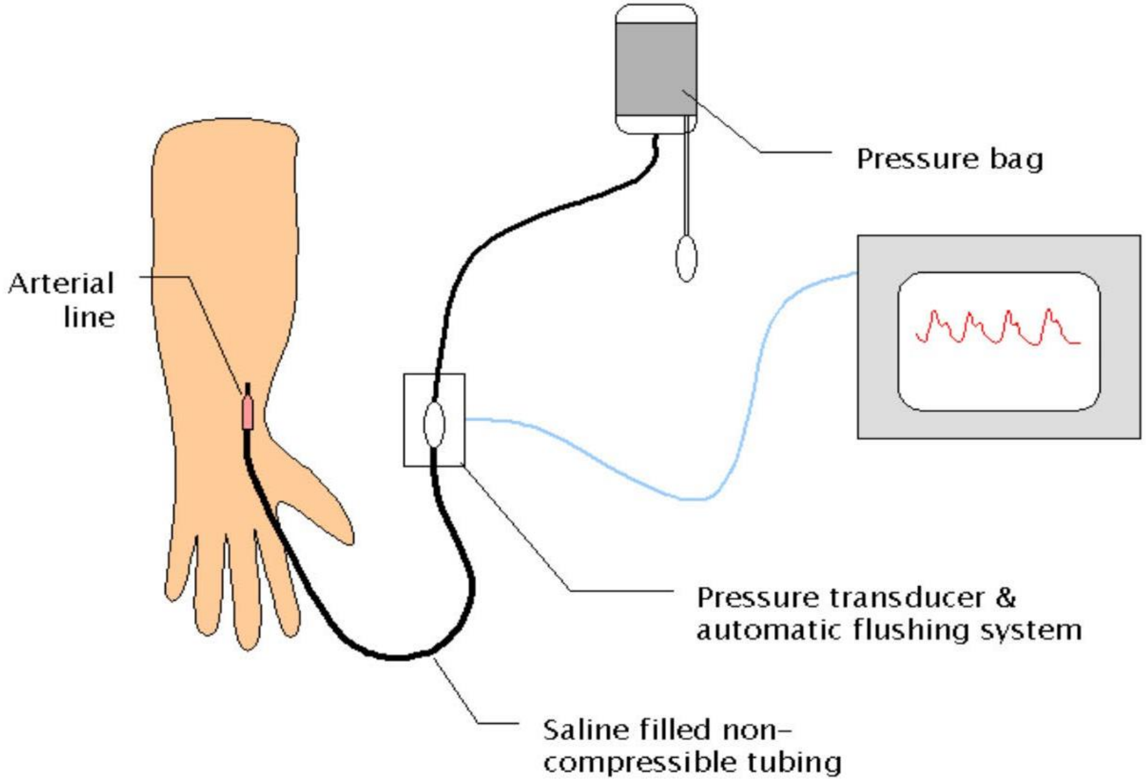

Asian Intensive Care International. (2009) Intensive Care Conference, Hong Kong. Retrieved: April 11, 2011. From: http://www.aic.cuhk.edu.hk/web8/haemodynamic%20monitoring%20intro.htm

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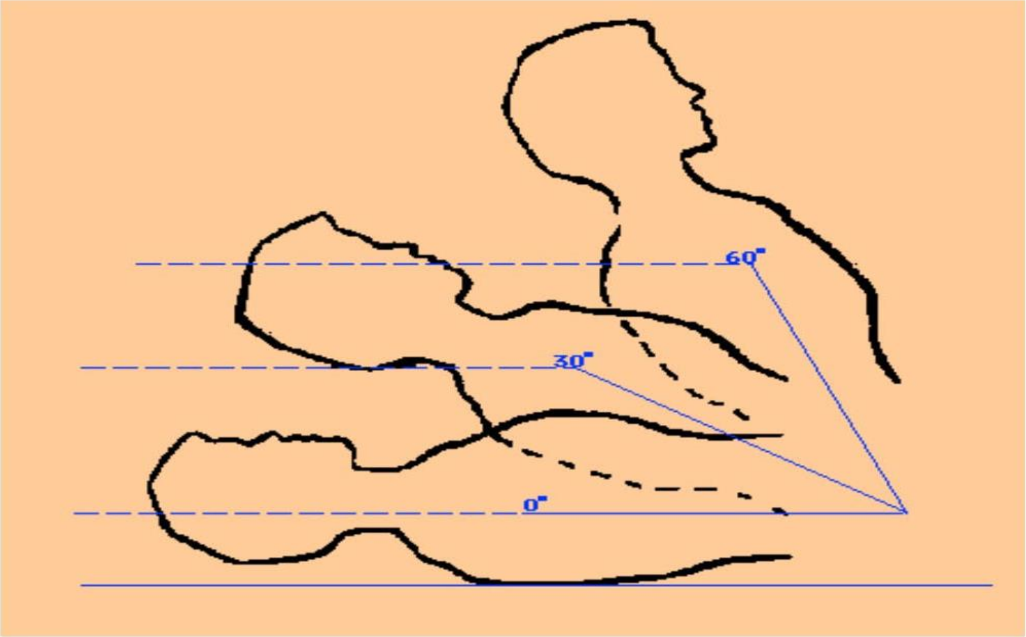
Schema of the phlebostatic level



Arterial catheter setup in adult. Schema of the phlebostatic level. *As the patient moves from the flat to the upright position, the phlebostatic level rotates on the axis and remains horizontal. The reference stopcock of the transducer must be levelled to the phlebostatic axis. Moving from supine to a sitting position changes the reference level and could lead to erroneous pressure measurements.*
From: Google images. (2011). Retrieved: April 11, 2011.

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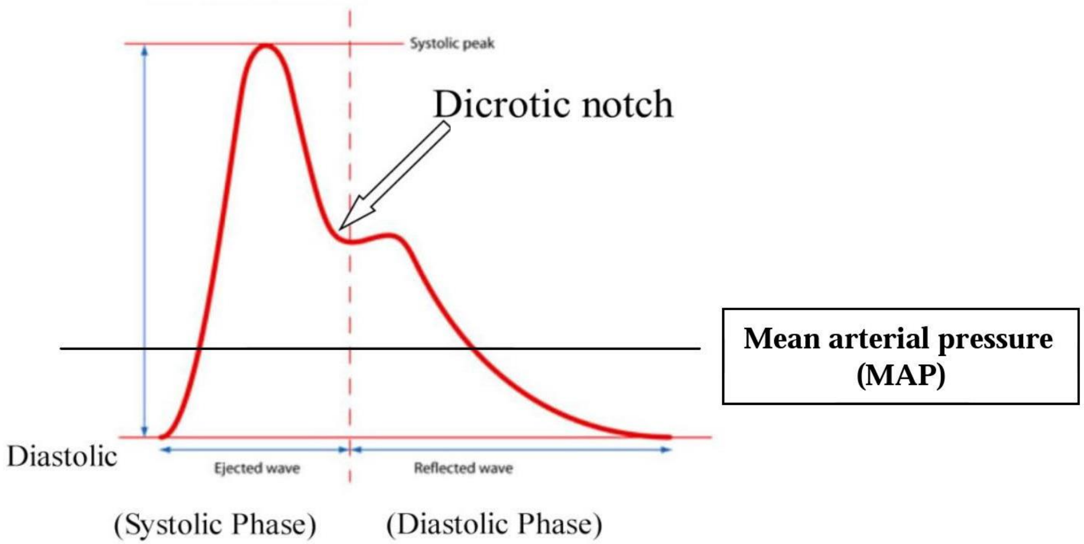
Invasive Arterial BP

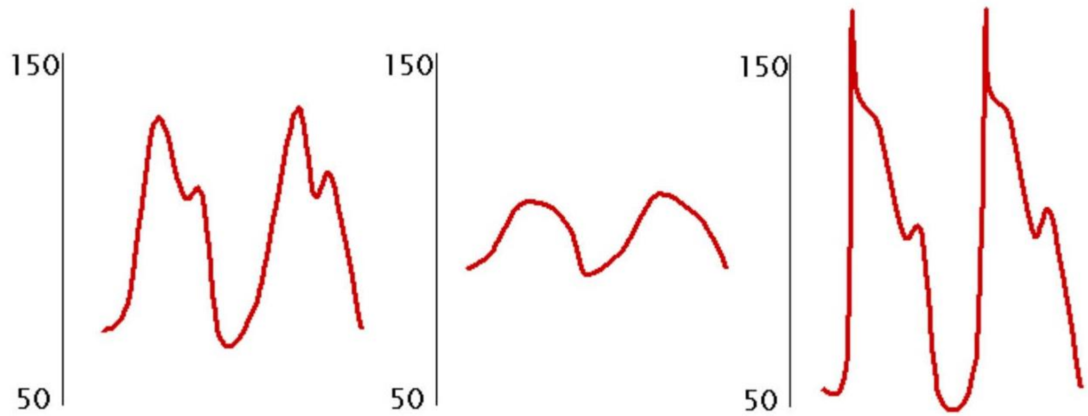
Normal arterial blood pressure wave



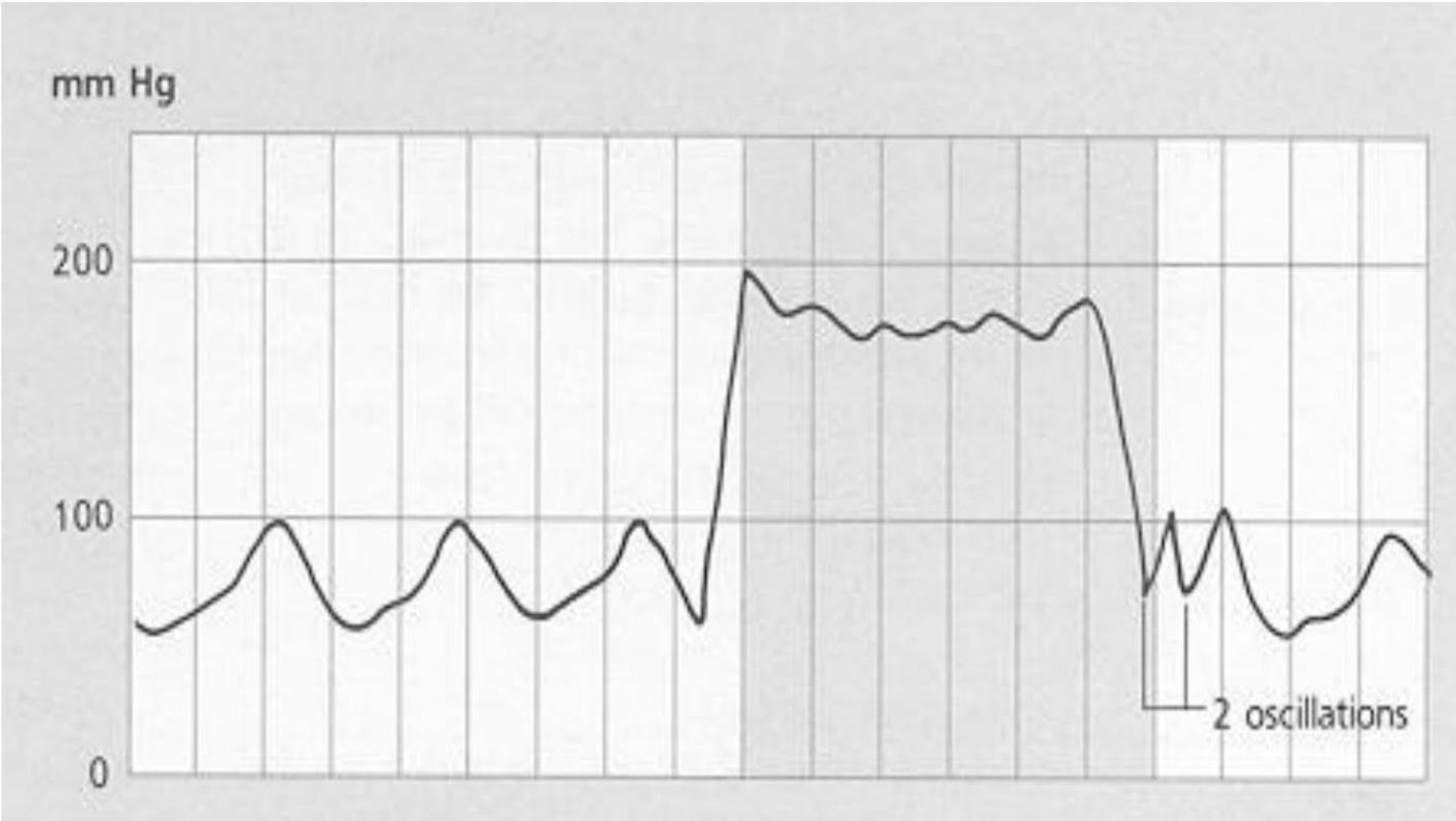
Google images. Retrieved: April 11, 2011. From: http://ericglenn.com/category/cardio-pulse-wave/.
Picture adapted by Paula Sanchez, RN, Liverpool ICU, 2011.

Dampening

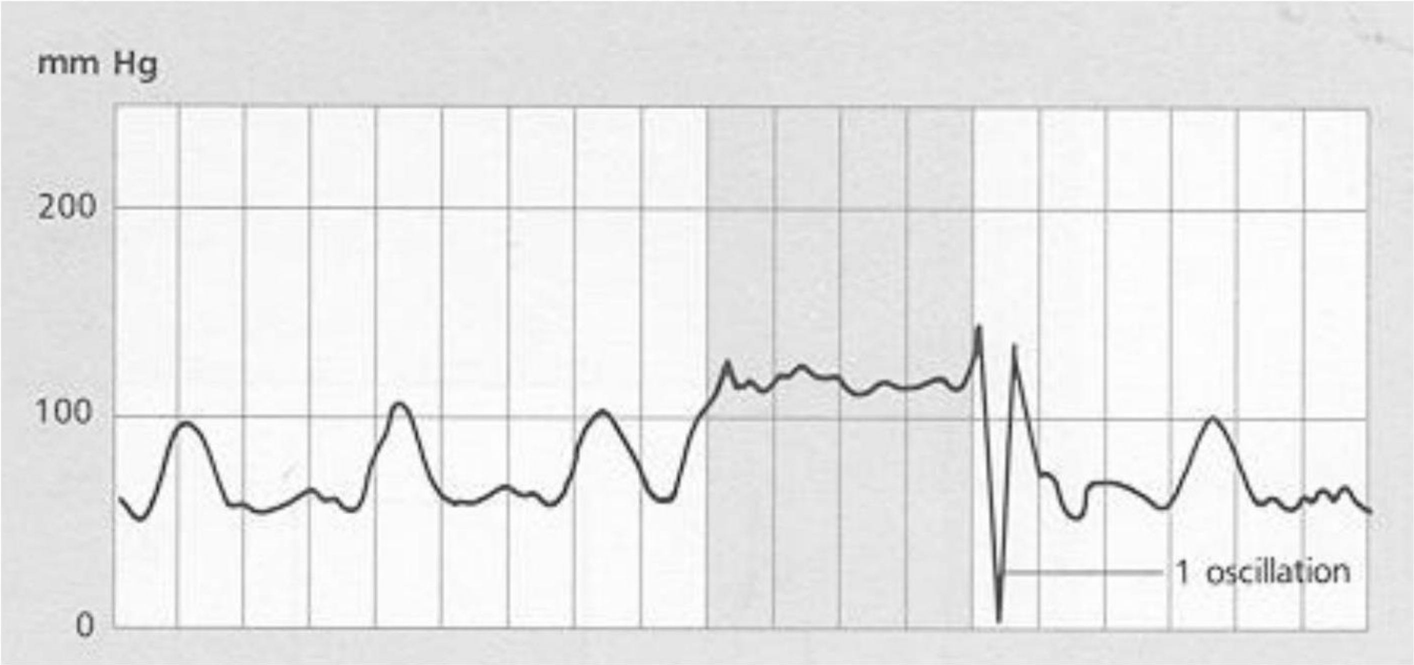
Comparing normal and abnormal arterial blood pressure waves



Asian Intensive Care International. (2009) Intensive Care Conference, Hong Kong


mm Hg
200
100
0
2 oscillations

Overdamped trace



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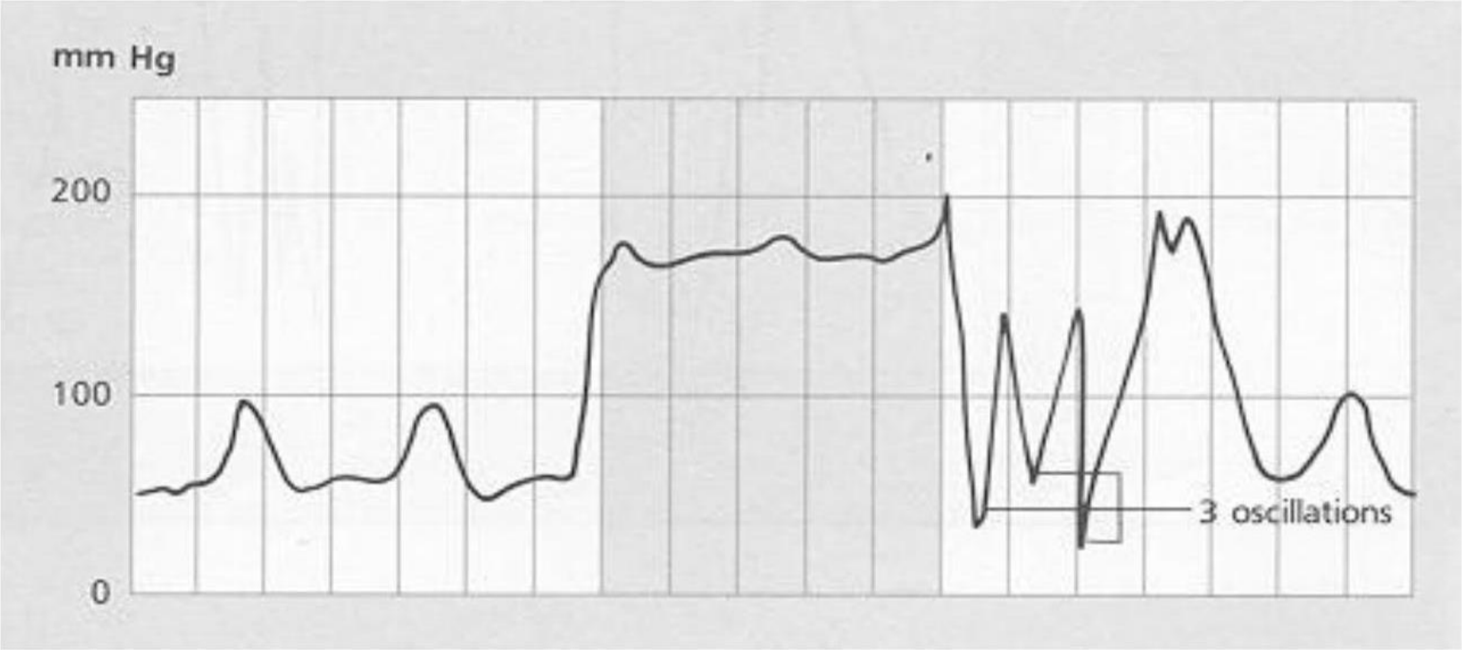
Underdamped tracing



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Invasive Arterial BP

- COMPLICATIONS:
  - Hemorrhage
  - Infection
  - Air Embolism
  - Distal ischemia

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NON-INVASIVE ARTERIAL BP

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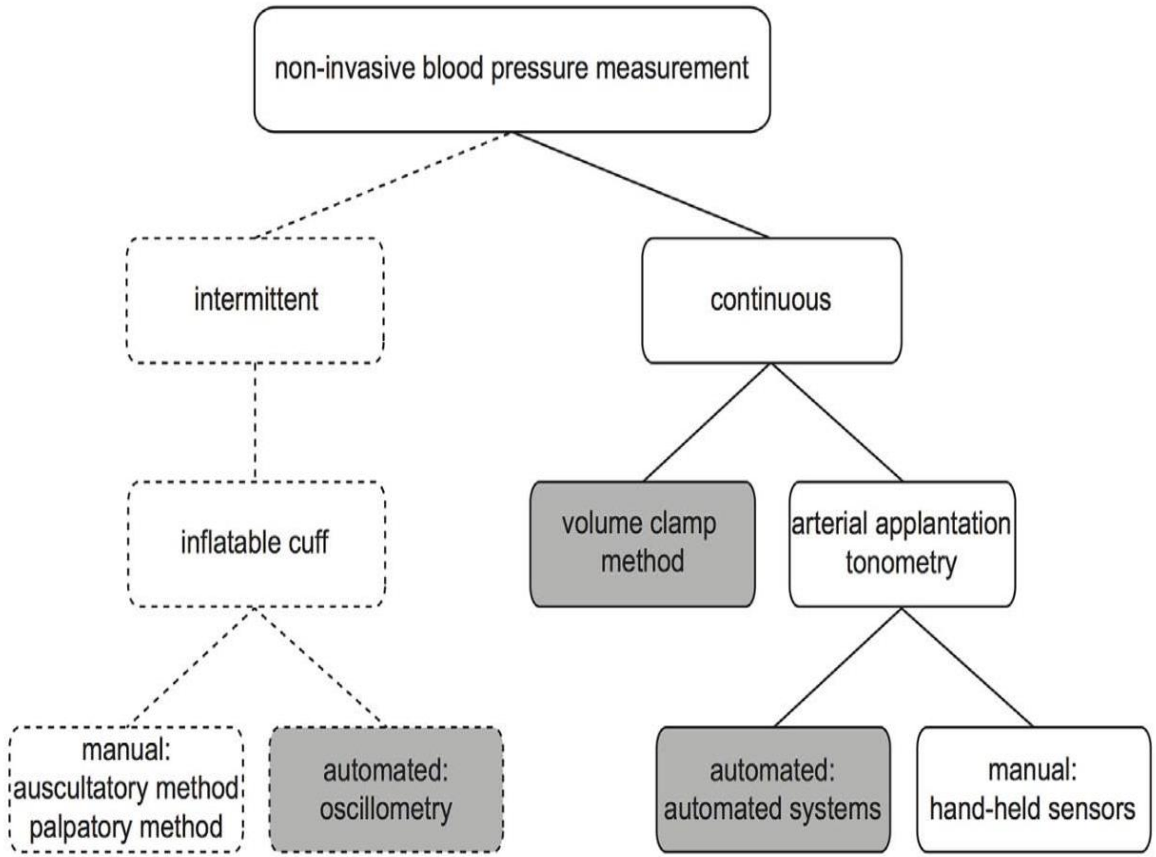

FIGURE 1 | Non-invasive blood pressure monitoring techniques.

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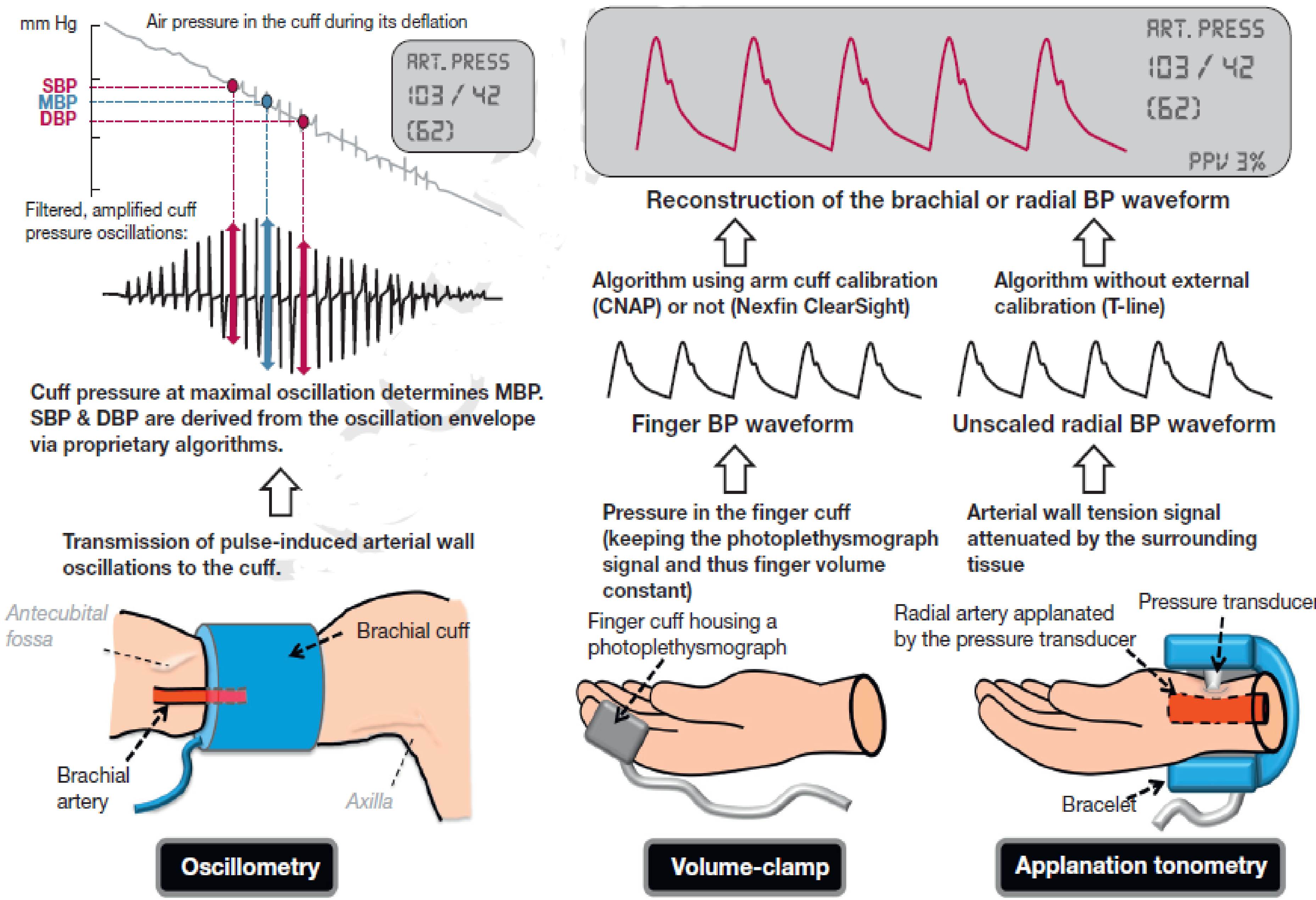


Figure 1 – *Oscillometric, volume-clamp, and applanation tonometry technologies. DBP = diastolic BP; MBP = mean arterial BP; SBP = systolic arterial BP.*

Intermittent NIBP

- Mean and diastolic BP measurements are often accurate and precise with modern NIBP devices. Mean BP readings should be preferred over systolic BP to guide therapy.
- NIBP reliably identifies hypotensive (mean BP <65 mm Hg or systolic BP <90 mm Hg) and hypertensive patients (mean BP >140 mm Hg).
- Arm NIBP reliably tracks therapy-induced changes in BP (>10% increase in mean BP).
- Even in specific circumstances such as arrhythmia (provided that triplicates are averaged), hypotension, vasopressor infusion and possibly in obese patients (provided that the cuff is carefully selected), arm NIBP could be useful.
- NIBP measurements are less accurate if the cuff is placed at the ankle or the thigh rather than at the arm.

Continuous NIBP

- Mean and diastolic BP measurements are consistently more accurate than systolic BP measurements. Mean BP readings should therefore be preferred over systolic BP to guide therapy.
- Whether continuous NIBP measurements are accurate & precise is uncertain.
- Provided that close recalibrations are automatically or manually performed, these fast-response devices may allow an early and reliable detection of acute changes in BP as alert signals, but may be misleading when considering the magnitude of the BP change in the event of abrupt changes.

Figure 2 – *Key messages for clinical practice. NIBP = noninvasive BP.*

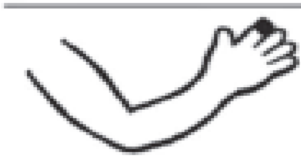
	Technique	Advantages	Limitations
	Oscillometric brachial cuff	Accurate non-invasive	Intermitent
	Arterial line	Gold-standard	Invasive
	Volume clamp	Non-invasive	Inaccurate expensive
	Physiological PWA	Non-invasive inexpensive deployed in OR	Under validation

Figure 1: Summary of available blood pressure (BP) monitoring technologies in the operating room.

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Noninvasive BP Monitoring in the Critically Ill

Time to Abandon the Intraarterial Catheter?

Karim Lakhal, MD; Stephan Ehrmann, MD, PhD; and Thierry Boulain, MD

REV 5.5.0 DTD ■ CHEST1416_proof ■ 28 November 2017 ■ 3:34 pm ■ EO: CHEST-17-1632

Techniques for Non-Invasive Monitoring of Arterial Blood Pressure

Agnes S. Meidert[1]* and Bernd Saugel[2]

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Questions?

- Invasive versus Noninvase
- Continuous versus Intermittent
- Arm vs Thigh vs Ankle

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Special Areas

- ICU
- Emergency Room
- Operating Room
- PACU/RR/SICU

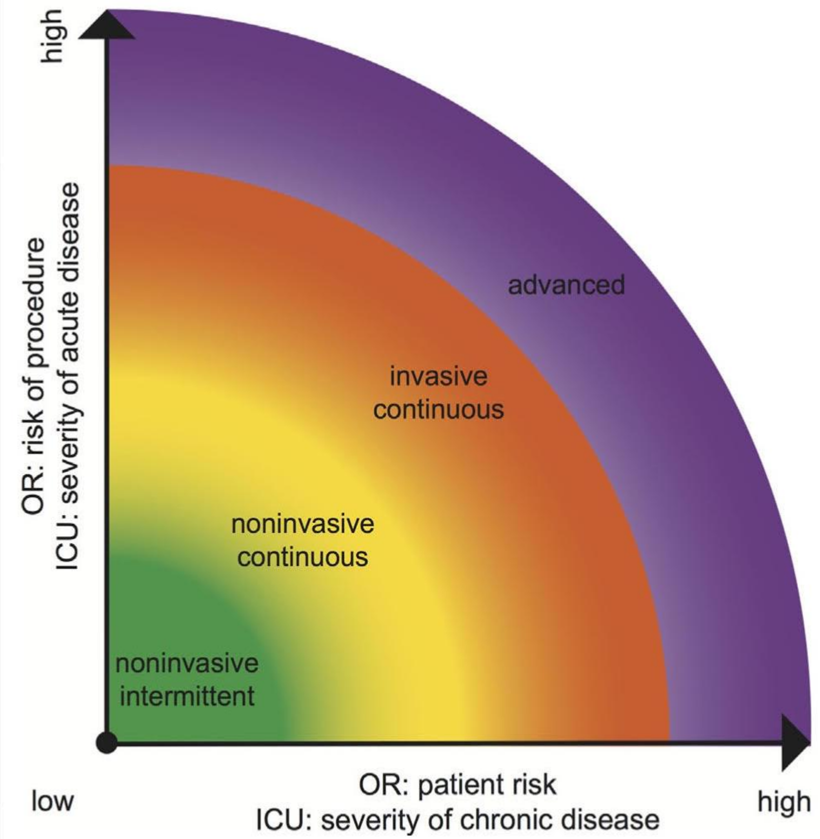

FIGURE 2 | Choice of adequate blood pressure monitoring equipment in ICU and OR according to patient and procedural risk (OR) (45) or chronic and acute disease (ICU).

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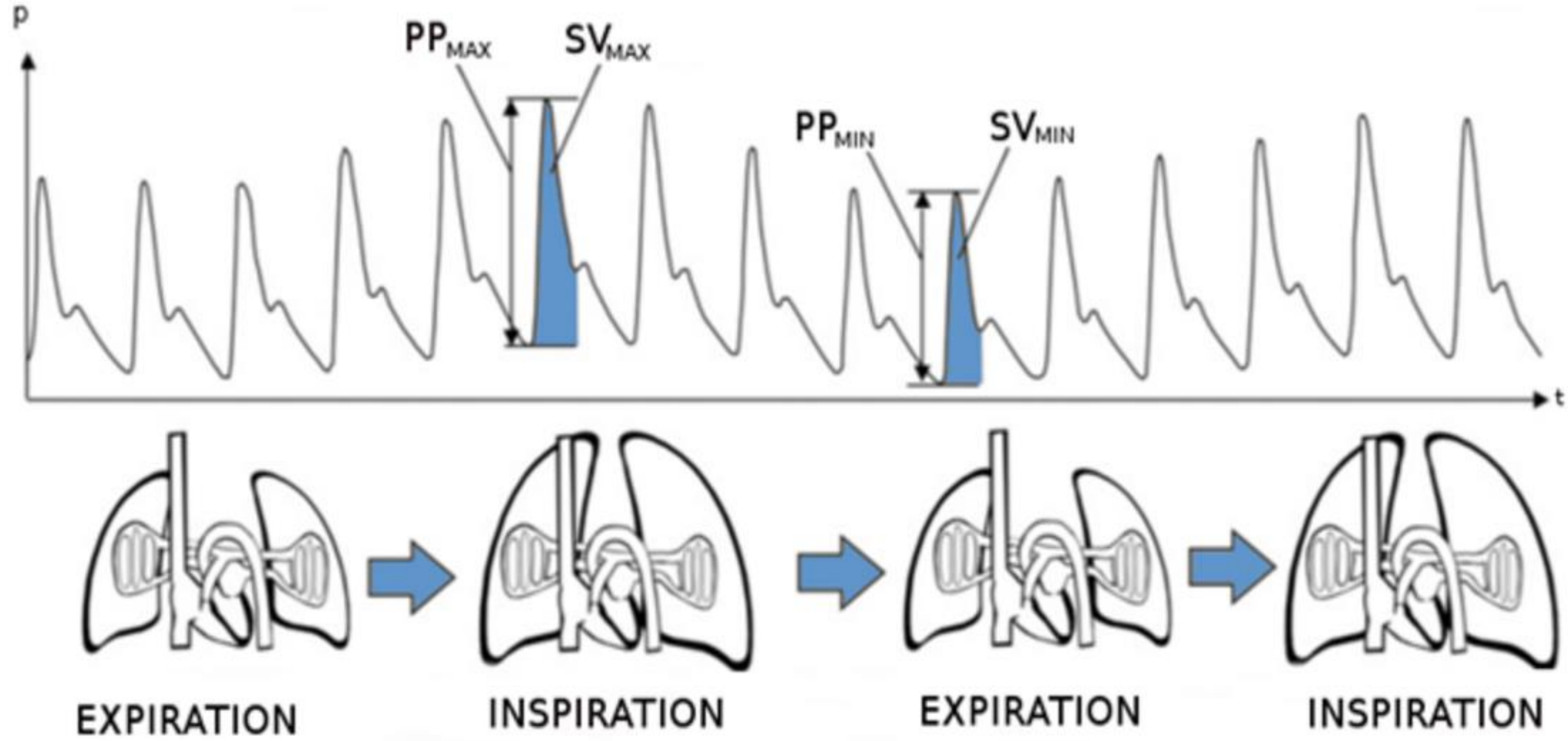

PULSE PRESSURE ANALYSIS

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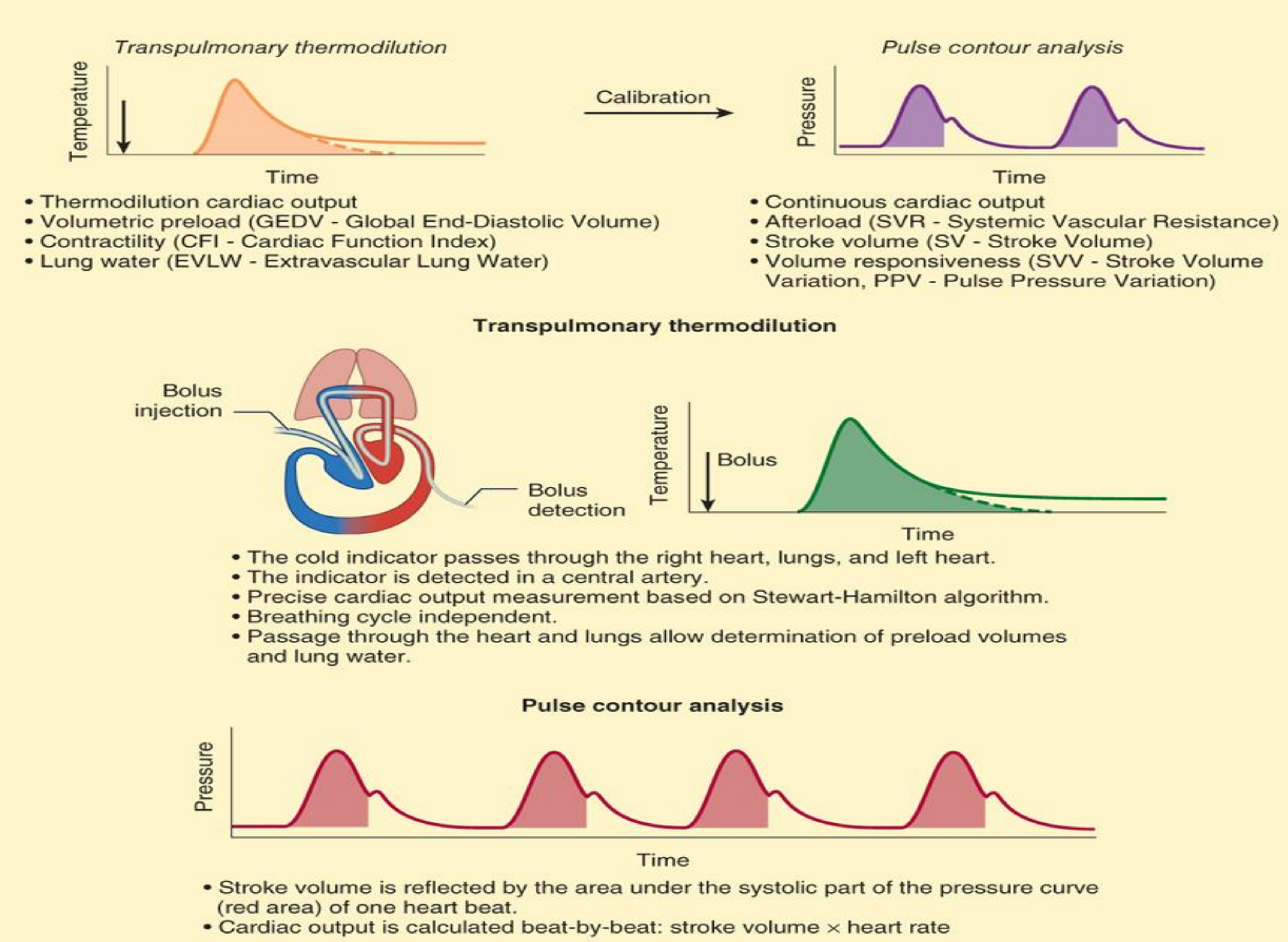

Source: J.F. Butterworth IV, D.C. Mackey, J. D. Wasnick: Morgan & Mikhail's Clinical Anesthesiology, 6th Edition.

ARTERIAL WAVEFORM ANALYSIS DEVICES

DETAILS	FloTrac, Edwards Life Sciences	PiCCO plus, Pulsion	Lidco Rapid, Lidco
Monitor	Vigileo	PulsioFlex	LidcoPlus
Algorithm All based on standard cardiac output equation (CO = SV x HR)	Arterial Pressure Cardiac Output (APCO). Uses standard deviation of arterial waveform data points.	Pulse Contour Cardiac Output (PCCO). Uses area under the systolic portion of the arterial waveform & shape.	Pulse Pressure Analysis (PulseCO). Uses Root mean square method applied to arterial pressure signal.
External Calibration	**N**, proprietary algorithm	**Yes**, transpulmonary thermal dilution	**Yes**, Lithium indicated dilution
Arterial Access	**Y**, any artery	**Y**, large peripheral (axillary, brachial, femoral).	**Y**, large peripheral (axillary, brachial, femoral).
Central Venous Access	*needed for +/- SVR & +/- ScVO2	**Y**, central venous catheter (CVC)	**Y**, central venous catheter (CVC)
Measured Values (all display continuous cardiac output & stroke volume)	Stroke Volume Variation (SVV) +/- Systemic Vascular Resistance (SVR) +/- ScVO2 ***note**- SVR & ScVO2 central venous access needed.	Pulse Pressure Variation (PPV) Stroke Volume Variation (SVV) SVR Global End Diastolic Volume (GEDI) Extravascular Lung Water (EVLW)	SV SVR +/- SVR
Advantages	Minimally invasive, can use any artery, easy to use, operator independent, no manual calibration.	Broad range of measured values. More robust during hemodynamic instability.	More robust during hemodynamic instability.
Disadvantages	Relies on optimal arterial waveform, less accurate during hemodynamic instability, less reliable in altered vascular tone.	Need CVC & larger artery, requires external calibration & recalibration. Operator dependent.	Need CVC & larger artery, requires external calibration & recalibration. Operator dependent. Interference with lithium.

Measured Values	Description/ Clinical Use
PPV or SVV	Assess Preload & volume responsiveness. A pulse pressure variation of 13% & stroke volume variation of 10% discriminates between responders & non-responders of fluid boluses. Useful for Early Goal directed therapy (EGDT) for resuscitation (septic protocols) and/or Goal directed fluid management (Enhanced Recovery after surgery).
SCVO2	Multi-faceted, shows adequacy of blood flow and most significant end-point of the "Surviving Sepsis" bundles. Can use as a guide for blood transfusion and inotropic therapy for myocardial dysfunction.
GEDI	Measure of blood volume in the heart. GEDI = Intrathoracic Thermal Volume-Pulmonary Thermal volume
EVLW	Used to quantify Pulmonary edema. Normal EVLW = 3-7ml/kg EVLW = Intrathoracic Thermal Volume-Intrathoracic Blood Volume

Scott Richey 2014

Thank you for your attention!

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