

2026 전공의 연수교육

Hemodynamic Monitoring in ICU

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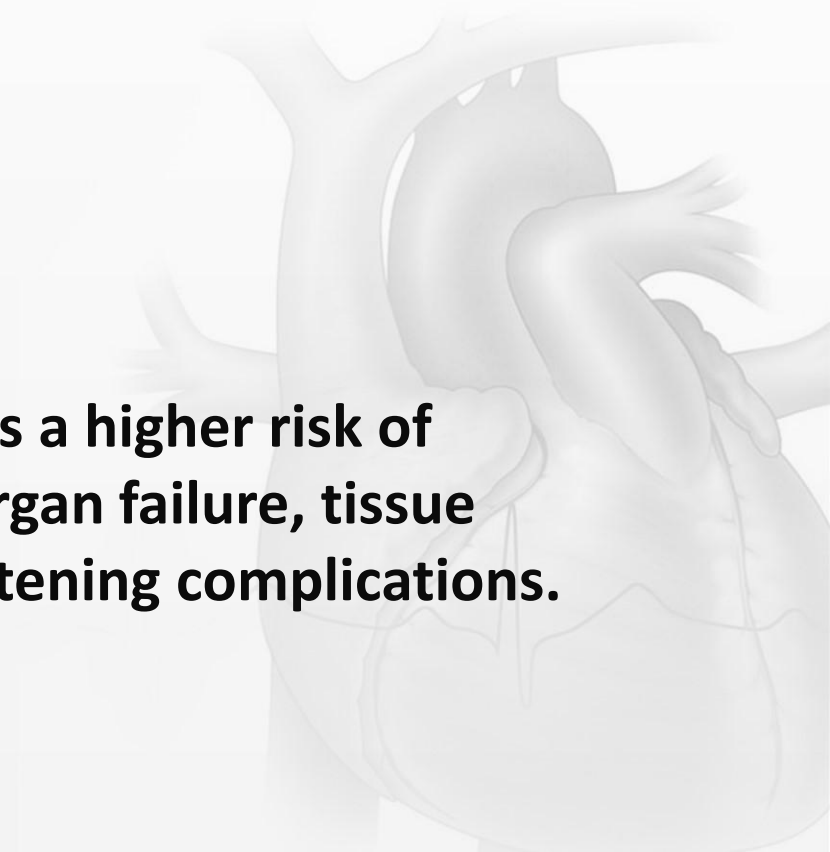
Hemodynamic stable vs. unstable

- BP, HR, SaO₂, RR

- BP; SBP (100-120mmHg)/DBP (60-80mmHg)
- HR; 60-100 beats/min
- SaO₂; 95-100%
- RR; 12-20 breaths / min

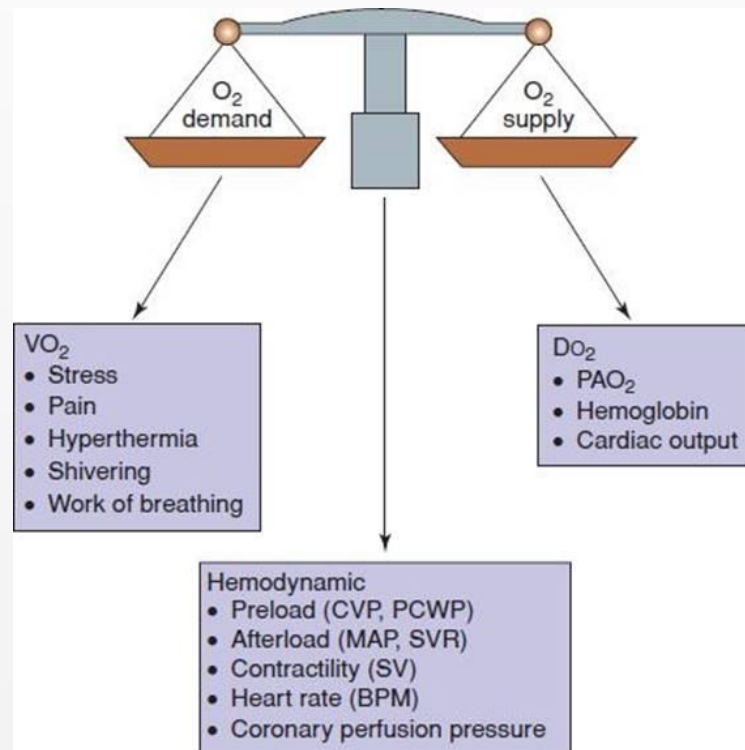
- Hemodynamic stability ???

- Hemodynamically unstable; there's a higher risk of **inadequate perfusion** leading to organ failure, tissue damage, and potentially life-threatening complications.



Shock

- **Clinical syndrome** characterized by **inadequate tissue perfusion** of oxygen and other nutrients, resulting in cellular injury and oxygen debt.
- **Defined** as a life-threatening acute circulatory failure characterized by decreased tissue perfusion, leading to inadequate oxygen delivery and/or oxygen utilization to meet cellular metabolic demands.



Signs and symptoms of Shock

Skin

- Pale
- Clammy
- Cool

Respiratory

- Rapid breathing
- Shallow respiration

Metabolism

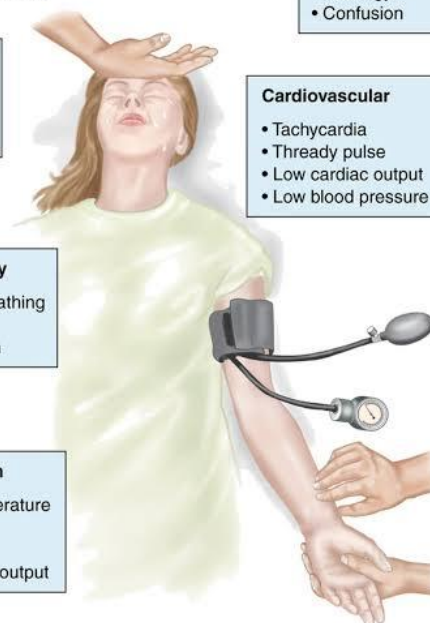
- Low temperature
- Thirst
- Acidosis
- Low urine output

Neurologic

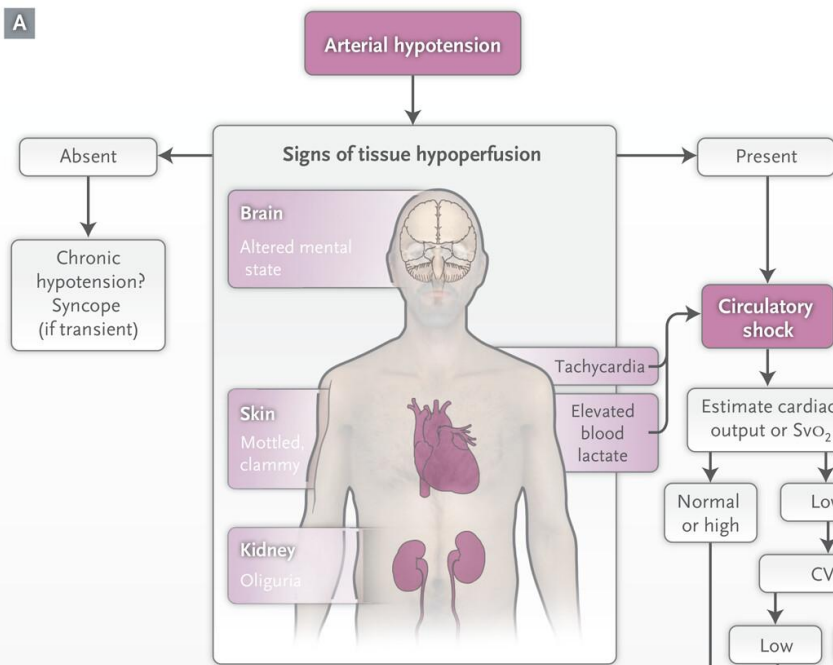
- Restlessness
- Anxiety
- Lethargy
- Confusion

Cardiovascular

- Tachycardia
- Thready pulse
- Low cardiac output
- Low blood pressure

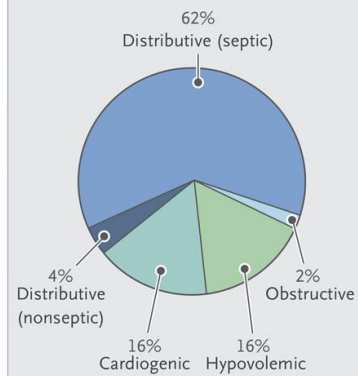


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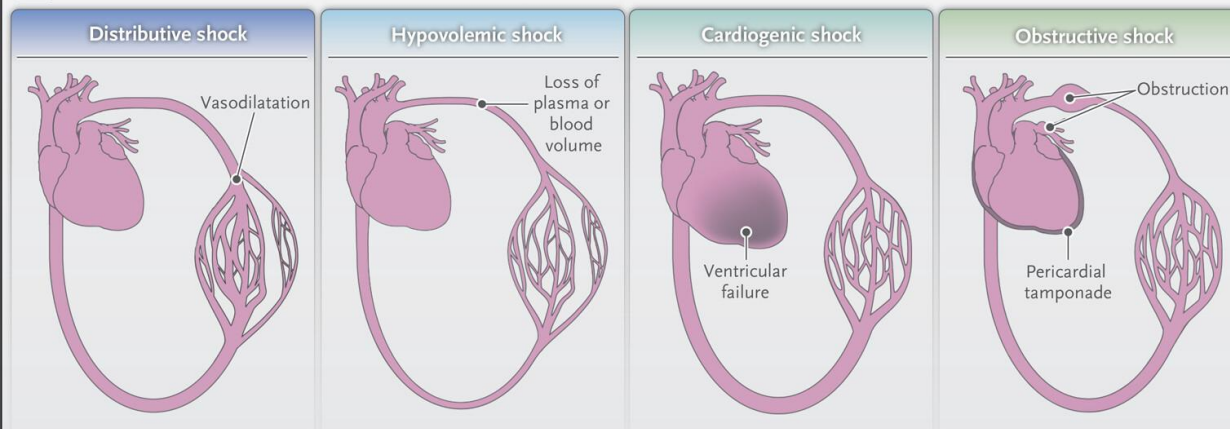


B

Types of shock



C



Hemodynamic monitoring in ICU

- **Effective monitoring** is the cornerstone of **quality critical care management** and allows the intensivist to make informed clinical treatment **decisions**.
- Despite the many options available, the utility of **most** hemodynamic monitoring is **unproven**.
- Identify **impending cardiovascular insufficiency**, its **probable cause**, and **response to therapy**.
- **Continuous** monitoring
- **Non-invasive** vs. **Invasive** modalities
 - Non-invasive; EKG, Pulse oximetry, NIBP, ETCO₂,
Sonography (+TTE), NIRS, BIS, Automated pupillometry
 - Invasive; A-lines, CVP, PAC, PiCCO
FloTrac sensor-Vigileo monitor, ICP & CSF pressure monitor

Table 1 Monitorin devices commonly used in the ICU setting

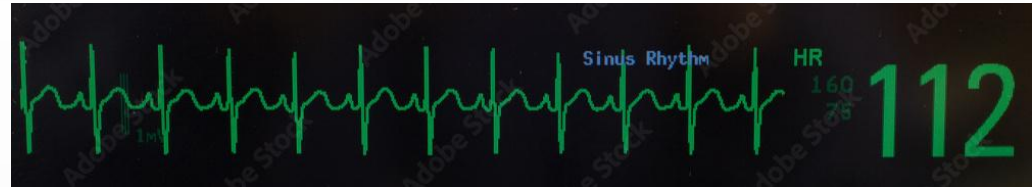
Monitoring modality	Invasive or non-invasive?	Parameters measured	Most accurate for	Risks of placement/use	Limitations
Arterial line	Invasive	SBP, DBP, MAP*, PPV*	SBP; DBP	Vessel injury, thrombosis, bleeding, infection	Positional, dampened waveform, clotting off
Central venous pressure	Invasive	CVP	Static pressure measurement	Risks inherent to central line, misinterpretation	PPV, intra-abdominal hypertension
Pulmonary artery catheter	Invasive	PAP, PCWP, SvO ₂ , CO*, CI*, thermodilution	PAP, SvO ₂ , thermodilution	Risks inherent to central line, cardiac arrhythmia, PA perforation	More invasive without improving outcomes
FloTrac	Invasive	SBP, DBP, MAP*, PPV*, CO*, SV*, SVR*, SVV*	SBP, DBP	Risks inherent to arterial line, misinterpretation	Arrhythmia, spontaneous respiration, open abdomen, vasopressors
Pulse contour cardiac output system	Invasive	Arterial line parameters, CVP, thermodilution, CO*, CI*, SV*, SVV*, EDV*	Arterial line parameter, CVP	Risks inherent to arterial line, risks inherent to central line	Must be calibrated with thermodilution, cardiac arrhythmia alters measurements, limitations inherent to arterial lines
ICP monitor	Invasive	ICP	ICP	Infection, parenchymal injury	Credentialing/specialization for placement
Continuous cardiac monitoring	Non-invasive	Electrical impulses, HR*	Electrical activity	Skin tears, skin irritation, misinterpretation, alarm fatigue	Motion artifact, high volume of clinically irrelevant information
Pulse oximetry	Non-invasive	Percentage of red and near-IR light absorbed between probe, SpO ₂ *, HR*, RR*	Oxyhemoglobin, deoxyhemoglobin	Minimal	Rare hemoglobinopathies, hemoglobin bound to molecules other than oxygen, low blood flow to extremities, arrhythmia (limits accuracy of HR), very low SpO ₂ , some nail polish colors
Oscillometric blood pressure monitor	Non-invasive	SBP*, DBP*, MAP	MAP	Discomfort to the patient with repeated measurements in the same place	Inappropriate cuff size, intermittent measurements only
Point of care ultrasound	Non-invasive	Direct distance between structures, size of structures, echogenicity of structures/fluid, direction of flow when using Doppler	Direct distance measurements and size measurements	Small amount of discomfort depending on the exam performed, hemodynamic changes with turning or moving the patient to obtain the window	Operator error or inexperience, air between probe and target structure, patient body habitus
Brain function monitors	Non-invasive	Electroencephalography*, level of sedation	Electroencephalographic waveforms	Skin irritation where electrodes are placed	Time delay between administration of new medication and calculation of new monitored value (not immediately concurrent), interference from other medical devices, hypothermia
Automated pupillometry	Non-invasive	Pupil size*, pupil reactivity, NPI	Pupil size	Misinterpretation	Cataracts, certain medications, inability to detect reactivity in very small pupils
Clinical decision support	Non-invasive	Dependent on the learning algorithm	Dependent on the learning algorithm	Alarm fatigue or 'click' fatigue	Patient populations not used in the learning or validation models

*Indicates directly measured values, other parameters are calculated based on monitor algorithms or calibration.

CI, cardiac index; CO, cardiac output; CVP, central venous pressure; DBP, diastolic blood pressure; EDV, end diastolic volume; HR, heart rate; ICP, intracranial pressure; IR, infrared; IR, infrared; MAP, mean arterial pressure; NPI, neurologic pupil index; NPI, Neurologic Pupil Index; PAP, pulmonary artery pressure; PCWP, pulmonary capillary wedge pressure; PPV, pulse pressure variation; RR, respiratory rate; SBP, systolic blood pressure; SpO₂, oxygen saturation of peripheral blood; SV, stroke volume; SvO₂, central venous oxygen saturation; SVR, systemic vascular resistance; SVV, stroke volume variation.

Electrocardiograph (ECG)

- Heart rate
- Arrhythmias
- Myocardial infarction
- Limitations
 - Skin irritation, sweating (patch detach), misinterpretation, alarm fatigue, motion artifact

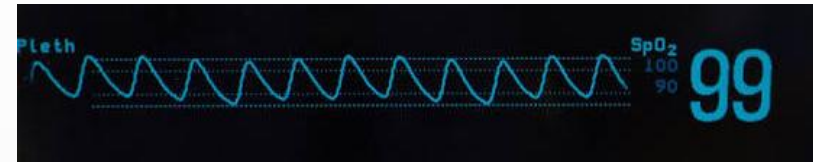


Pulse oximetry (SpaO₂)

- Percentade of red and near-infrared light absorbed between probe

- Limitations

- inability to differentiate between hemoglobins other than **oxy-hemoglobin and deoxy-hemoglobin** (carboxyhemoglobin, sickle hemoglobin, methemoglobin)
- Less accuracy in cases of very **low oxygenation** (< 70%), physiologic factors such as compromised perfusion to the extremities (**severe hypotension, hypothermia, low cardiac output, vasoconstriction**), and even certain **nail polish colors** (blue, black, green)



Oscillometric Non-Invasive Blood Pressure (NIBP)

- NIBP cuff
- most accurate in determining the **mean arterial pressure**, and less so the systolic or diastolic pressure, as the mean pressure is measured by the oscillometer, whereas the systolic/diastolic numbers are mathematically derived from proprietary algorithms.
- Limitations
 - Times for measurement
 - Arrhythmias
 - appropriately **sized cuff** relative to the patient's arm
 - Inner inflatable bladder length; cover 75% to 100% of the arm's circumference, width; 40% of the arm circumference.
 - False high pressure; cuff too small



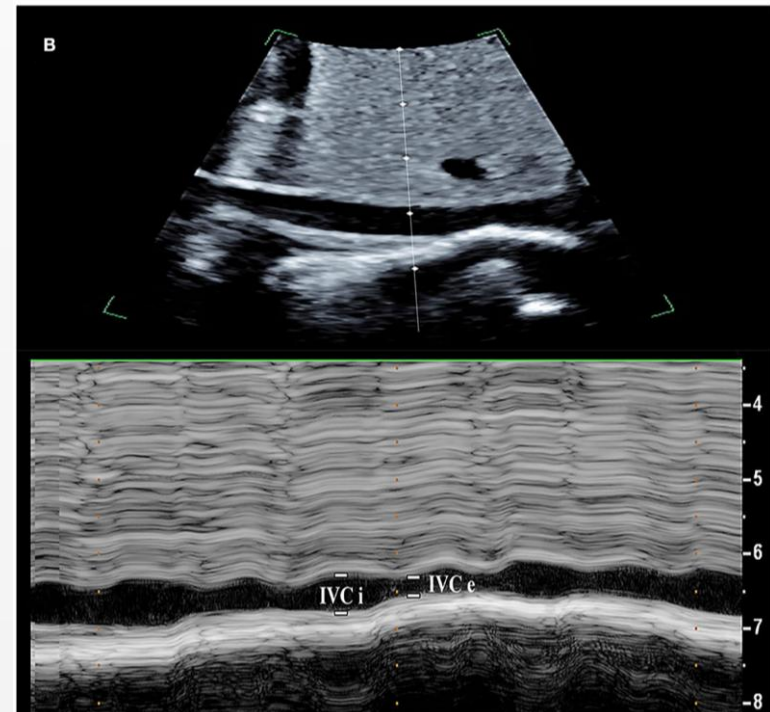
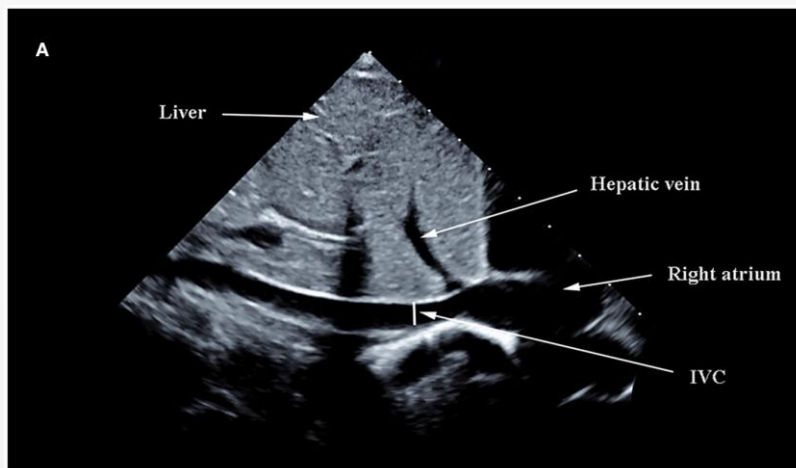
End-Tidal Capnography (ETCO₂)

- Capnography is a measurement of carbon dioxide concentration during the respiratory cycle, displayed as a waveform on a monitor
- Limitations
 - difference between **PaCO₂** and **ETCO₂**



Point-of care Ultrasound (POCUS)

- Bed-side, portable, anytime, noninvasive, real-time
- LV and RV function, CO
- Evaluate volume status and fluid responsiveness by measuring the diameter of the inferior vena cava and lung sono (B-line)
- Pericardial effusion, pleural effusion, pneumothorax



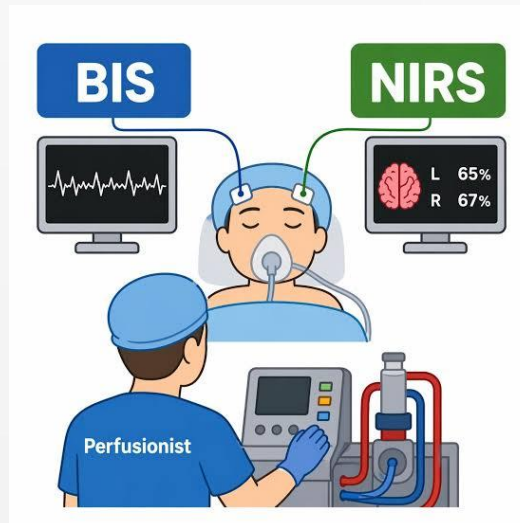
BIS, NIRS

- **BIS; bispectral index**

- help limit oversedation, prevent undersedation during periods of neuromuscular blockade, and potentially minimize sedative use with the goal of reducing delirium.

- **NIRS; near-infrared spectroscopy**

- Monitors regional tissue oxygenation reflecting perfusion status



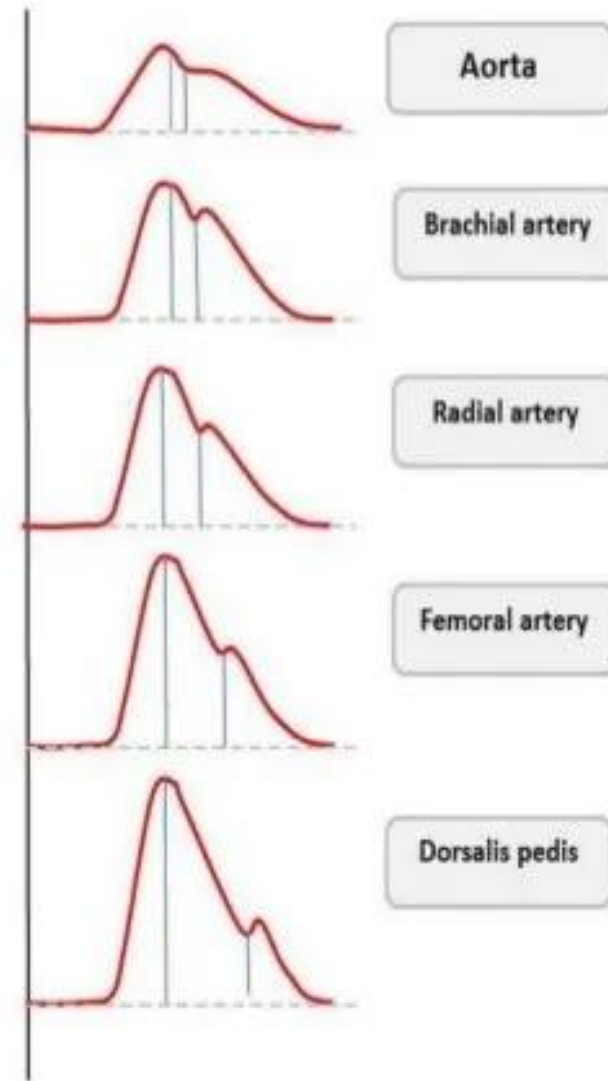
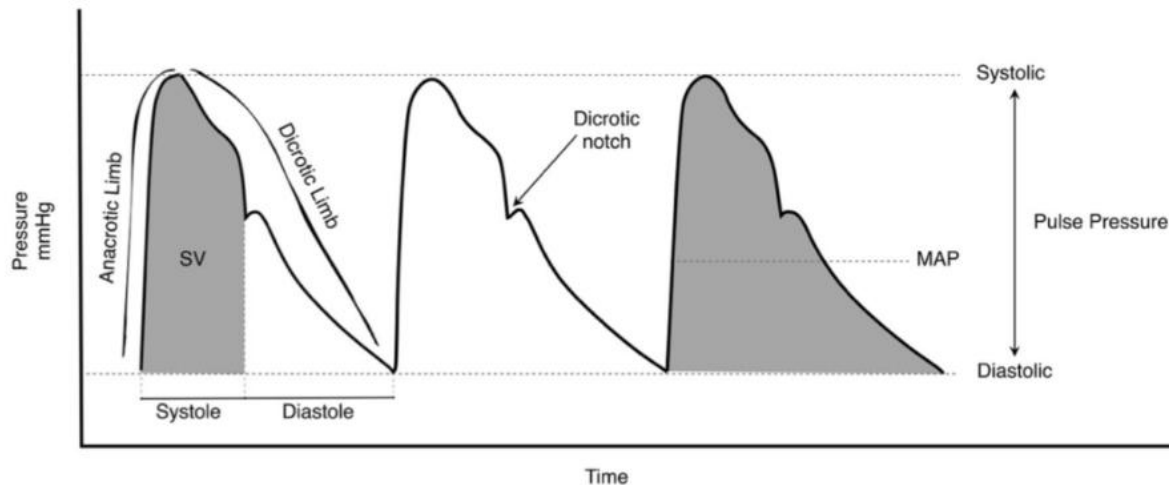
Automated pupillometry

- the measurement of pupil size and reactivity and serves as a non- invasive tool for monitoring neurologic status in patients with brain injury
- rapid, non-invasive, **reliable, and quantifiable assessment** of pupillary function
 - minimizes interobserver variability and can help standardize measurement across the care team.



Arterial lines (1)

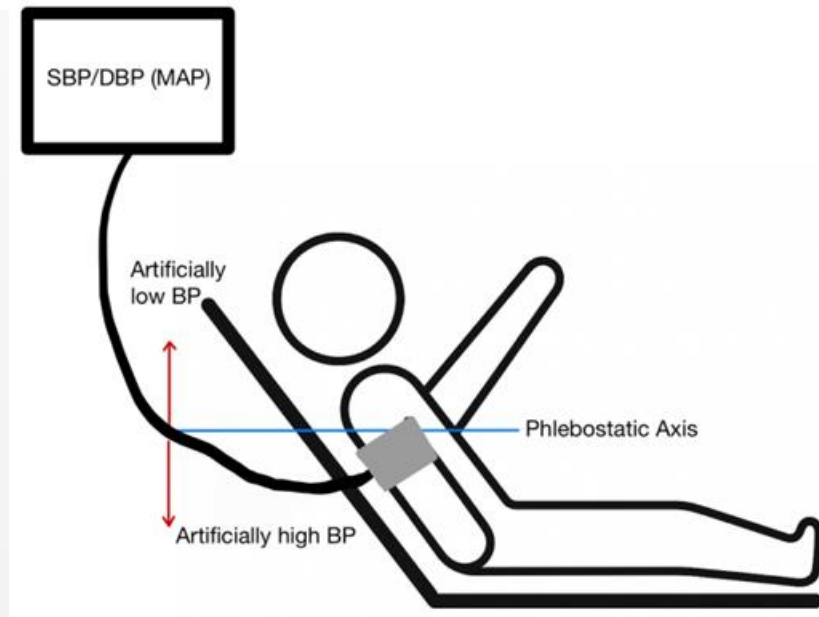
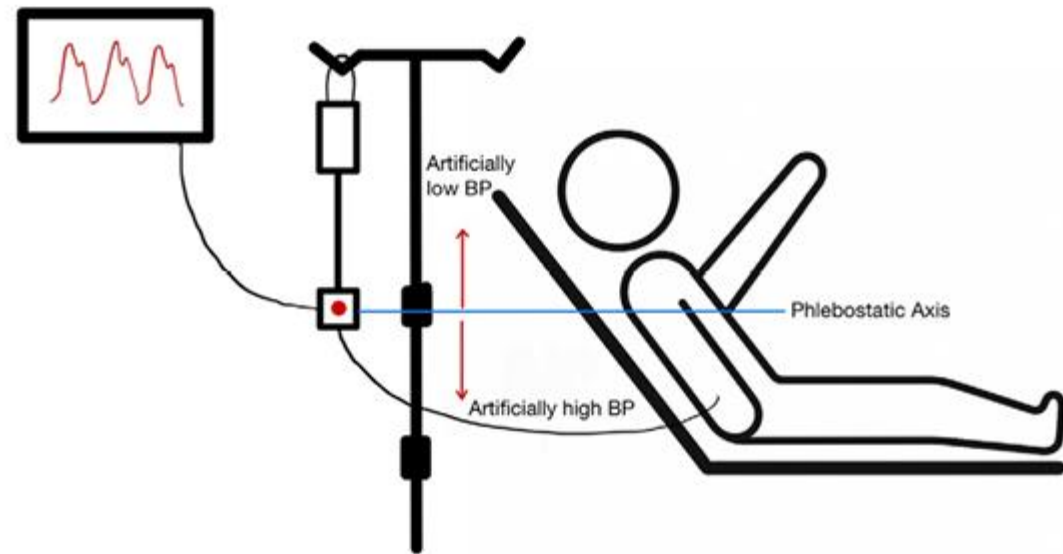
- Continuous **real-time blood pressure** monitoring
- Lab test including **ABGA**
- Risks include arterial injury, bleeding, thrombosis, arterial insufficiency, distal tissue ischemia, and bloodstream infection.



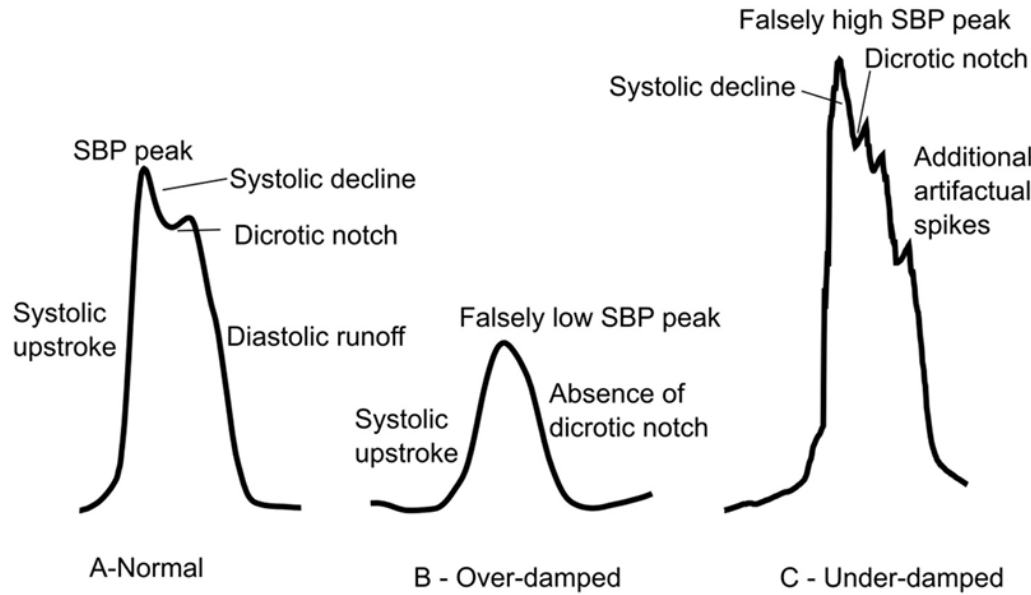
Arterial lines (2)

- Appropriate positioning of an arterial line pressure **transducer**.

- **phlebostatic axis**; 4th intercostal space, midaxillary line
- below phlebostatic axis- falsely high blood pressure
- above phlebostatic axis- falsely low blood pressure



Arterial lines (3)



● Over-damped

- 관로 내에 기포(Air bubble)가 차 있는 경우 (가장 흔함, 기포가 압력을 흡수함)
- 카테터 끝이 혈관벽에 닿아있거나 꺾인 경우 (Kinking)
- 라인 내부에 혈전(Clot)이 생겨 막히기 시작한 경우
- 압력 수액백의 압력이 떨어졌을 때 (300 mmHg 미만)
- 연결 튜브가 너무 길거나 말랑 말랑한 재질인 경우

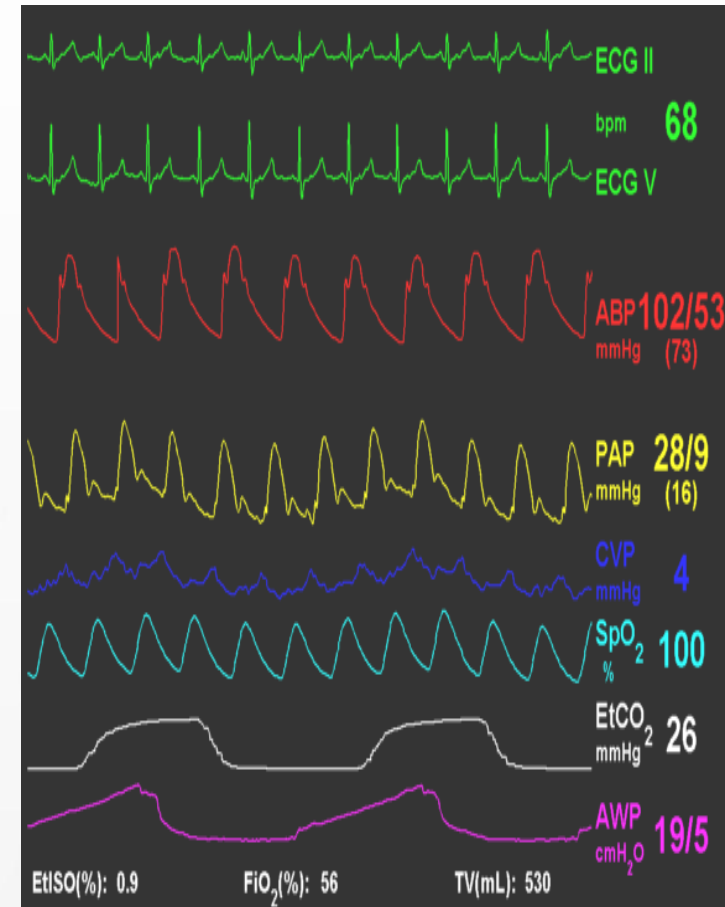
● Under-damped

- 연결 튜브가 필요 이상으로 너무 딱딱한(Rigid) 경우
- 카테터가 심장 박동이나 강력한 혈류 때문에 혈관 내에서 심하게 흔들리는 경우 (Catheter whip)
- 주사기 연결 부위(Stopcock) 등 연결 부속이 너무 많은 경우
- 환자가 빈맥(Tachycardia)이거나 심박출량이 매우 높은 상태인 경우

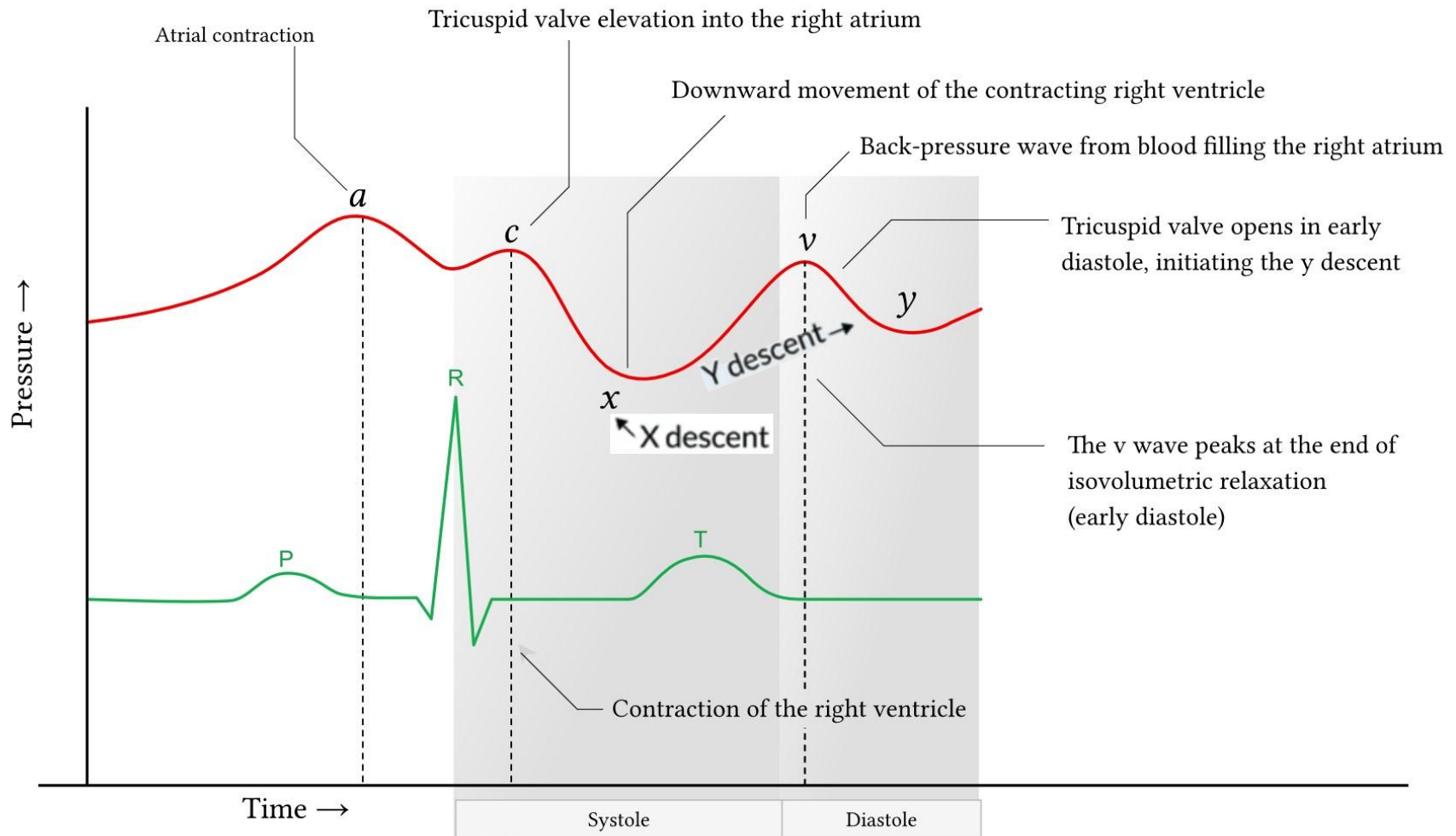
구분	Over-damped (과도 감쇠)	Under-damped (과소 감쇠 / Fling / Whip)
파형 형태	뭉개지고 완만함 (둥글둥글함)	뾰족하고 급격함 (아티팩트 침상파 발생)
디크로틱 노치	보이지 않거나 희미함	여러 개로 쪼개지거나 과장됨
수축기 혈압(SBP)	실제보다 낮게 측정됨 (False Low)	실제보다 높게 측정됨 (False High)
이완기 혈압(DBP)	실제보다 높게 측정됨 (False High)	실제보다 낮게 측정됨 (False Low)
평균 동맥압(MAP)	정확하게 유지됨 (왜곡 거의 없음)	정확하게 유지됨 (왜곡 거의 없음)

Central venous pressure (CVP) (1)

- Administration of **certain medications, venous blood sampling**, monitoring
- CVP; pressure in the **SVC or RA**.
 - assess volume status, approximate preload, Predict fluid responsiveness
- **Influence factors**
 - positive pressure ventilation, intraabdominal & intrathoracic pressure
- Risk
 - central line- associated blood stream infection
 - central line- associated venous thrombosis
 - air embolism
- Causes of raised CVP
 - Right ventricular failure, Tricuspid stenosis or regurgitation
 - Pericardial effusion or constrictive pericarditis
 - Superior vena caval obstruction
 - Fluid overload
 - Hyperdynamic circulation
 - High PEEP settings

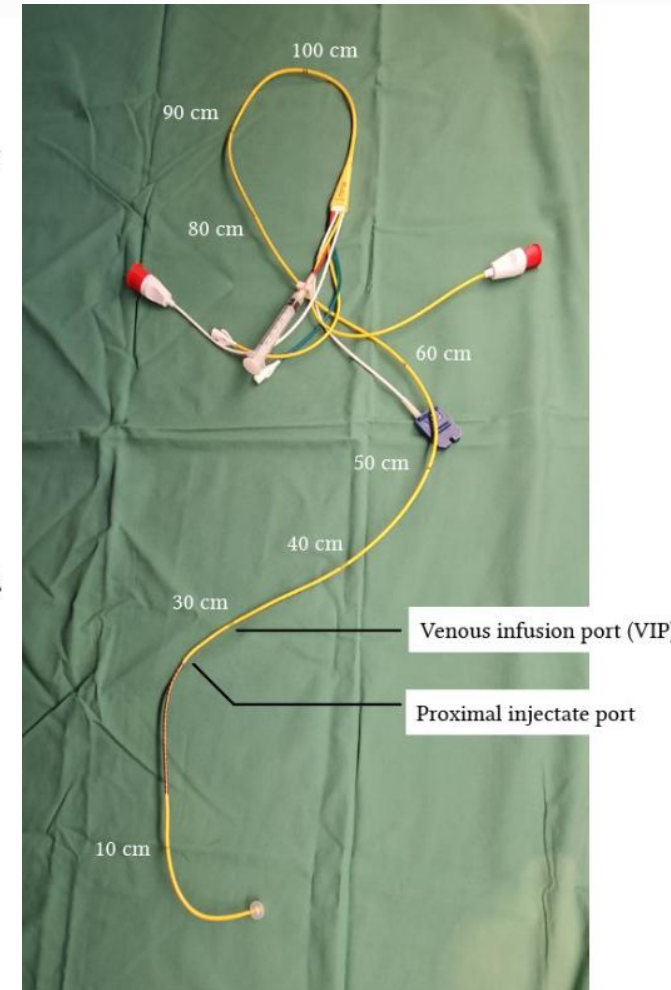
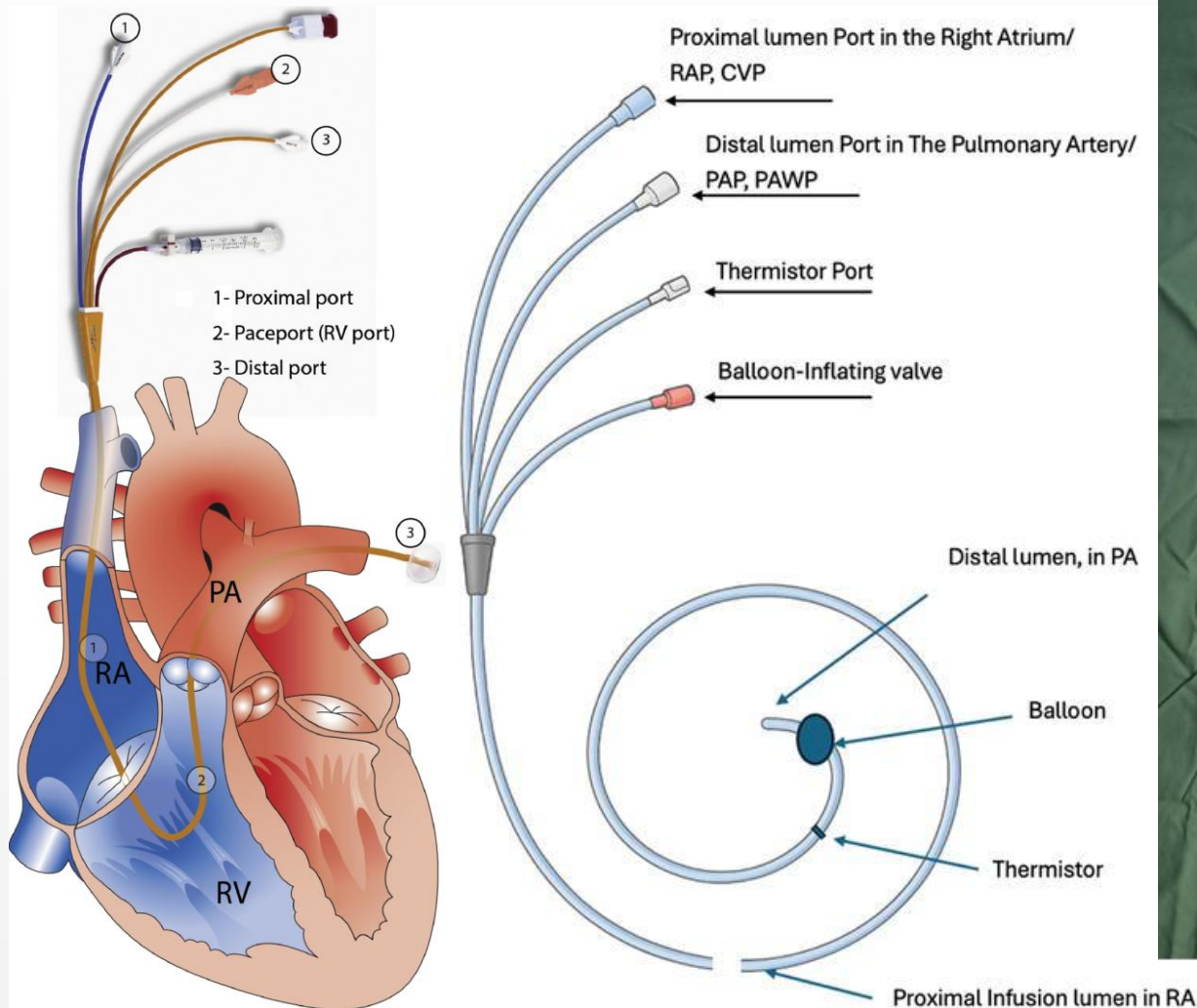


Central venous pressure (CVP) (2)

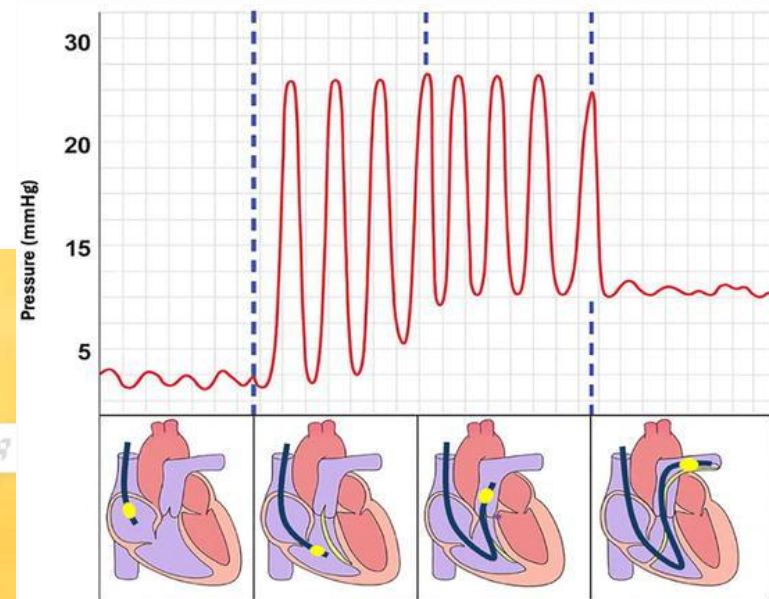
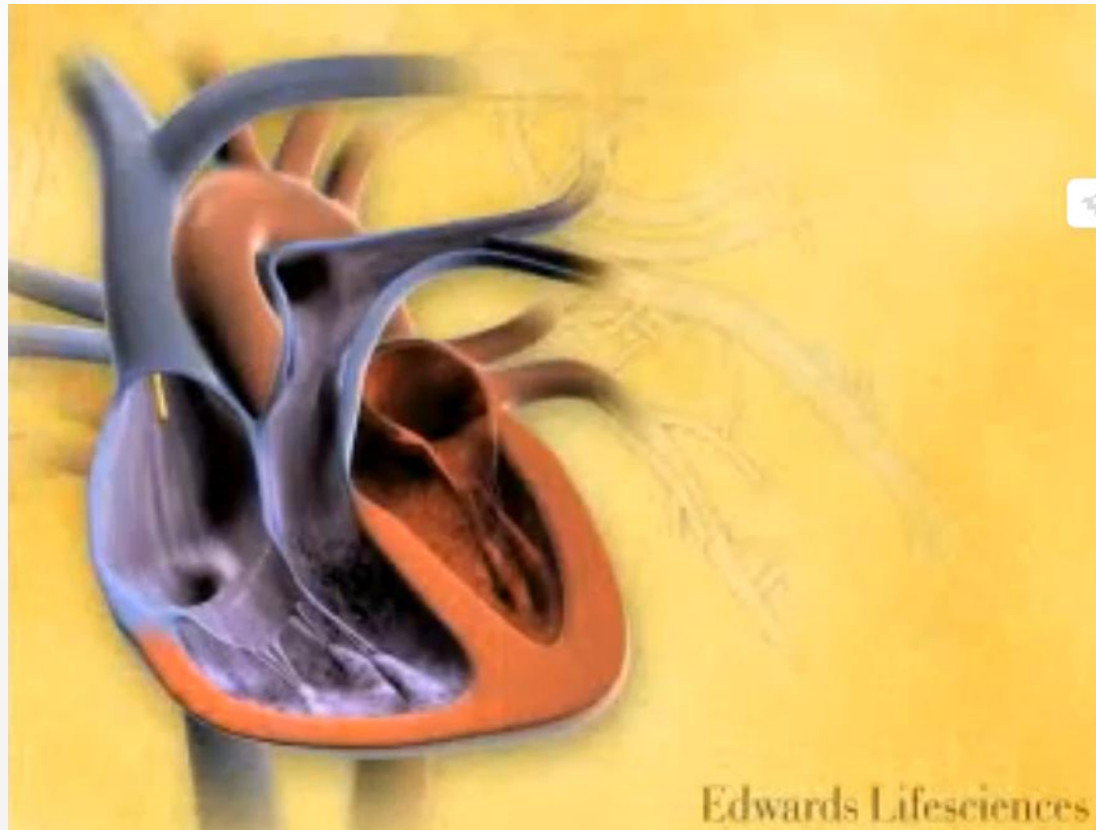
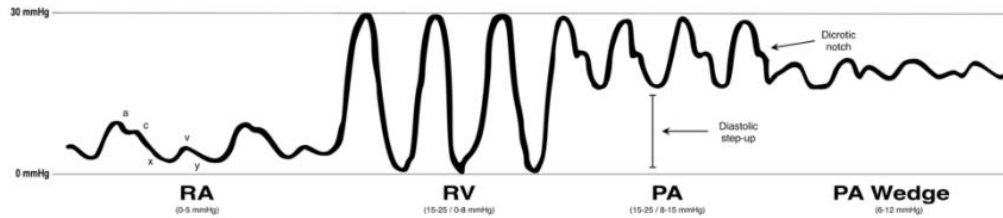


Pulmonary artery cath (PAC) (1)

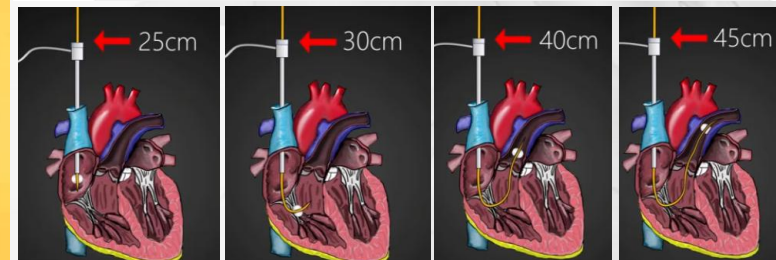
● Swan-Ganz catheter



Pulmonary artery cath (PAC) (2)



Right Atrium	Right Ventricle	Pulmonary Artery	Pulmonary Artery Wedge
0-6 mmHg	25/0 mmHg	15-30 / 5-15 mmHg	2-10 mmHg



Edwards Lifesciences

Pulmonary artery cath (PAC) (3)

- One of the most reliable techniques for hemodynamic monitoring

- Direct measurement;

- RAP or CVP; 2-6 mmHg
- RVP; S 15-30 / D 0-8 mmHg
- PAP; S 15-30 / D 5-15 mmHg (m 10-20mmHg)
- PCWP(=LA pressure, LVEDP); 6-12 mmHg
- Core Body Temperature

- Calculated Value;

- CO; 4-8 L/min (CI; 2.5-4.0 L/min/m²)
- SvO₂; 60-80%
- SVR; 800-1200 dynes·sec/cm⁵ (SVRI 1900-2400 dynes·sec/cm⁵/m²)
- PVR; 40-150 dynes·sec/cm⁵ (0.25 – 1.5 Wood units)



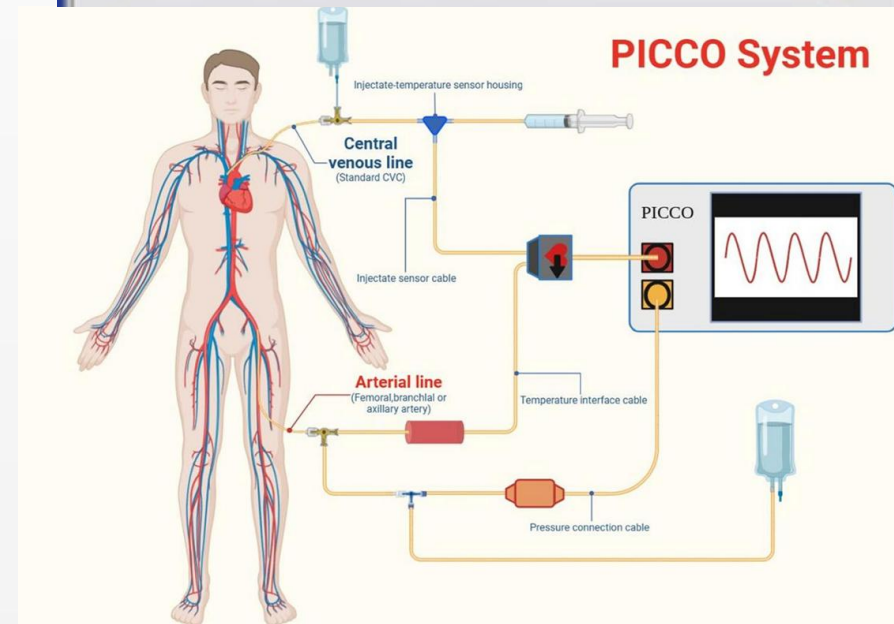
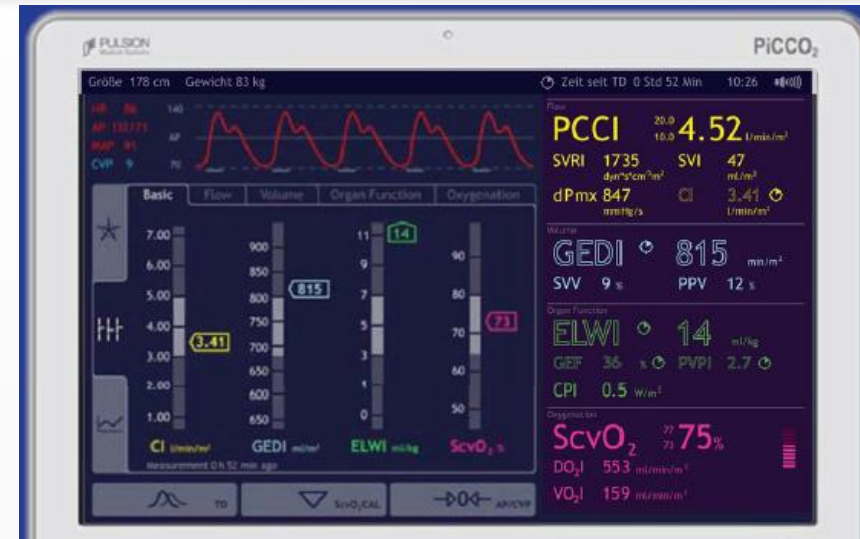
$$SVR = \frac{MAP - CVP}{CO} \times 80$$

$$PVR = \frac{(mPAP - PCWP)}{CO} \times 80$$

PiCCO (Pulse contour cardiac output system)

● peripheral A-line, C-line

- CI; 3.0-5.0 L/min/m²
- SVI; 40-60 mL/beat/m²
- SVV; <10%
- SVRI; 1970-2390 dyn·sec/cm⁻⁵/m²
- GEDVI; 680-800 mL/m²
- EVLWI; 3-7ml/kg (<10ml/kg)

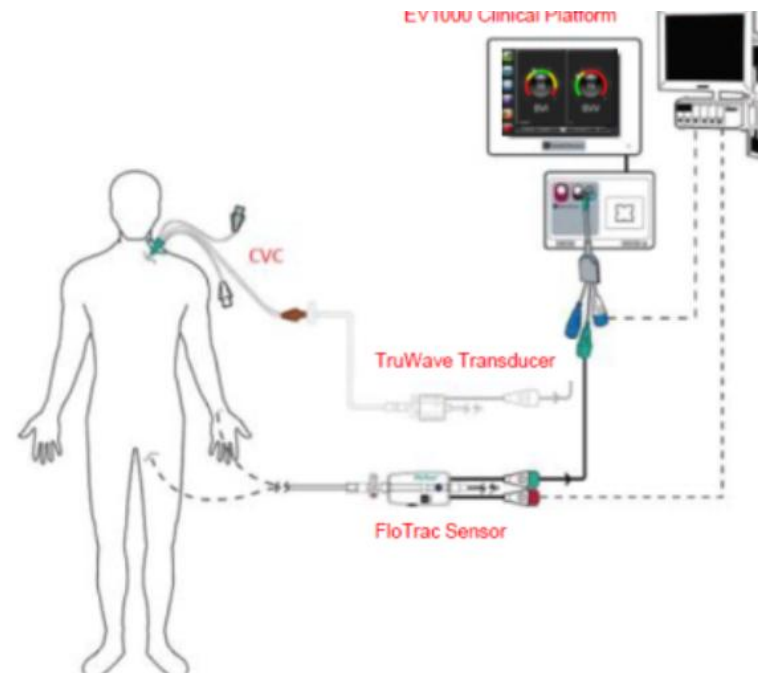


FloTrac sensor-Vigileo monitor (EV1000)

● peripheral A-line, C-line

- SV, SVI; 60-100 ml/beat, 33-47/ml/m²/beat
- SVV; 10-15%
- SvO₂; 60-80%
- CO, CI; 4.0-8.0 L/min, 2.5-4.0L/min/m²
- SVR, SVRI; 800-1200 dynes·sec/cm⁻⁵

1970-2390 dynes·sec/cm⁻⁵/m²



PAP vs. PiCCO vs. FloTrac/Vigileo

System	Invasiveness	Key Indicators	Core Clinical Significance	Limitations
PiCCO System	Moderate (requires arterial and central venous catheters)	1. Preload Indicators:	Advantages in volume management; more accurate in reflecting preload than pressure parameters; quantifies pulmonary edema	Requires calibration (every 8 hours), complex operation, steep learning curve
		GEDVI: 680–800 ml/m ²		
		EVLWI: 3–7 ml/kg		
		PVPI: 1–3		
		2. Afterload Indicators:		
		SVRI: 1700–2400 dyn·s·cm ⁻⁵ ·m ²		
Pulmonary Artery Catheter (PAC)	High (requires catheterization of the internal/jugular/subclavian vein)	1. Direct pressure indicators:	Gold standard but highly invasive; assesses left preload; differentiates cardiac/non-cardiac pulmonary edema	High complication risk (arrhythmias, embolism), not suitable under severe valvular regurgitation
		CVP: 2–8 mmHg		
		PAWP: 6–12 mmHg		
		2. Volume responsiveness indicators:		
		CI: 2.5–4.0 L/min/m ²		
		3. Oxygen metabolic indicators:		
		SvO ₂ : 65–75%		
FloTrac/Vigileo	Low (requires only arterial catheterization)	1. Heart output related indicators:	Convenient for dynamic monitoring; no need for central venous access; quick assessment	Errors during arrhythmias; not suitable for low peripheral resistance states
		CO/CI: 2.5–4.0 L/min/m ²		
		2. Oxygen metabolic indicators:		
		SvO ₂ : 65–75%		
		3. Dynamic monitoring indicators:		
		SVV: ≤10% (volume adequacy indicator)		
		PPV: ≤13% (volume responsiveness threshold)		

Table 3 Comprehensive overview of key hemodynamic variables in thermodilution monitoring

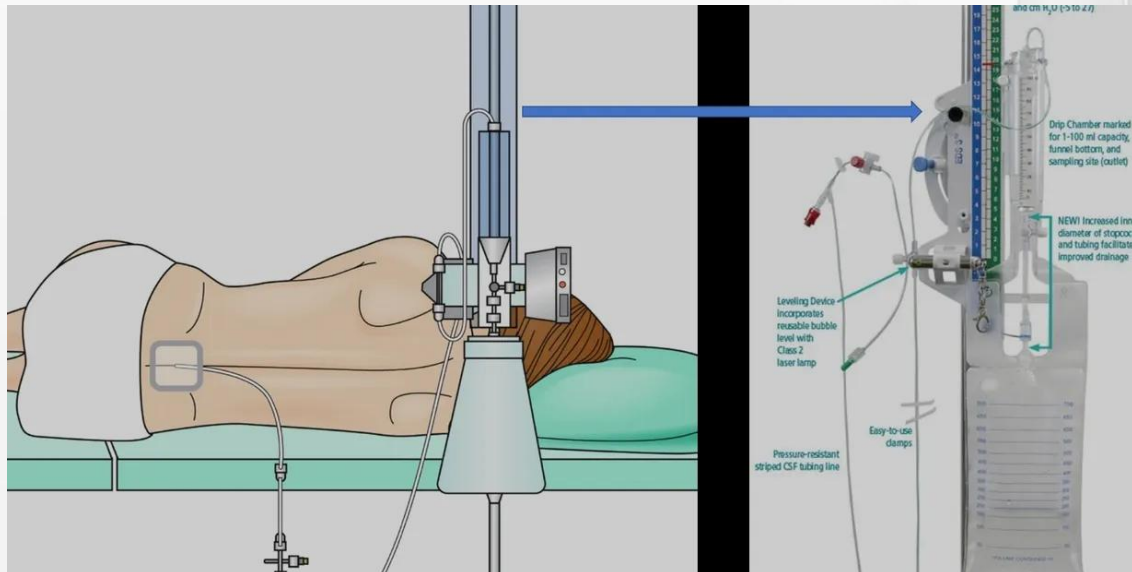
Parameter	Unit	Assessment/Calculation	Physiological Role	Physiological Range
Cardiac Output (CO)	L/min	HR x SV	Global blood flow from the heart	4–8
Cardiac Index (CI)	L/min/m ²	CO/BSA	CO indexed to body surface area for individual assessment	2,5–3,5
Oxygen Content (CaO ₂)	ml/dl	(1.36×Hb×SaO ₂)+(0.0031×PaO ₂ in mmHg)	Represents oxygen carried in arterial blood	21
Oxygen Supply (DO ₂)	ml/min	COx[(1.36×Hb×SaO ₂)+(0.0031×PaO ₂ in mmHg)]	Total oxygen delivery to the tissues per minute	950–1150
ScvO ₂	%	Direct measurement (PAC)	Surrogate for systemic oxygen balance (O ₂ delivery vs. demand)	70–80%
Systemic Vascular Resistance (SVR)	dyn·s·cm ⁻⁵	80 × (MAP–CVP)/CO	Afterload of left ventricle; reflects vascular tone	800–1200
Systemic Vascular Resistance Index (SVRI)	dyn·s·cm ⁻⁵ ·m ²	80 × (MAP–CVP)/CI	SVR adjusted for body surface area	1400–2500
Pulmonary Vascular Resistance (PVR)	dyn·s·cm ⁻⁵	80 × (MPAP–PAOP)/CO	Afterload of right ventricle; pulmonary vascular tone	20–130
Pulmonary Vascular Resistance Index (PVRI)	dyn·s·cm ⁻⁵ ·m ²	80 × (MPAP–PAOP)/CI	PVR adjusted for body surface area	255–285
Central Venous Pressure (CVP)	mmHg	Direct measurement (CVC)	Right atrial pressure; reflects preload and volume status	2–8
Pulmonary Artery Pressure (PAP)	mmHg	Direct measurement (PAC)	Pressure in pulmonary artery; reflects RV function and resistance	15–25/8–15
Mean Pulmonary Artery Pressure	mmHg	Direct measurement (PAC)	Average pressure in pulmonary artery; used in PH diagnosis	10–20
Pulmonary Artery Occlusion Pressure (PAOP)	mmHg	Measured during balloon inflation	Reflects left atrial pressure; surrogate for LV preload	6–12
Global End-Diastolic Volume (GEDV)	mL	ITTV – PTV = CO × (MTt – DSt)	Volumetric preload indicator	800–1200
Global End-Diastolic Volume (GEDVI)	mL/m ²	(ITTV - PTV)/BSA	GEDV indexed to body surface area	680–800

Intrathoracic Blood Volume Index (ITBVI)	ml/m ²	GEDV × 1.25	Indicator of central blood volume	850–1000
Extravascular Lung Water (ELW)	mL	ITTV – ITBV	Marker of pulmonary edema	<500 ml
Extravascular Lung Water Index (ELWI)	mL/kg	(ITTV - ITBV)/bodyweight	Marker of pulmonary edema	<10 ml/kg
Stroke Volume Index	ml/m ²	SV/BSA	Output per heart beat	40–60
Stroke Volume Variation (SVV)	%	(SV _{max} – SV _{min})/SV _{mean} × 100	Dynamic preload indicator, fluid responsiveness predictor	≤10–12
Pulse Pressure Variation (PPV)	%	(PP _{max} – PP _{min})/PP _{mean} × 100	Dynamic preload indicator; assesses fluid responsiveness	≤13%
Right Ventricular Ejection Fraction (RVEF)	%	SV _{RV} /EDV _{RV} (via PAC)	Assesses right ventricular systolic function	≥45%

This table provides a detailed summary of essential hemodynamic parameters used in thermodilution and advanced hemodynamic monitoring. It includes units of measurement, calculation methods, physiological significance, and normal reference ranges. The listed parameters support clinical interpretation in critically ill patients and perioperative settings by describing preload, afterload, contractility, and global perfusion. CO: Cardiac Output; CI: Cardiac Index; Hb: Hemoglobin; SaO₂: Arterial oxygen saturation; PaO₂: Arterial oxygen partial pressure; MAP: Mean Arterial Pressure; CVP: Central Venous Pressure; MPAP: Mean Pulmonary Artery Pressure; PAOP: Pulmonary Artery Occlusion Pressure; ITTV: Intrathoracic Thermal Volume; GEDV: Global End-Diastolic Volume; ITBV: Intrathoracic Blood Volume; EVLW: Extravascular Lung Water; PPV: Pulse Pressure Variation; RVEF: Right Ventricular Ejection Fraction; ITTV: Intrathoracic Thermal Volume=the total thermal volume within the thorax; PTV: Pulmonary Thermal Volume=the thermal volume of the pulmonary circulation; MTt: Mean Transit Time=average time of thermal indicator transit; DSt: Downslope Time=exponential decay time of the thermodilution curve

CSF pressure monitoring

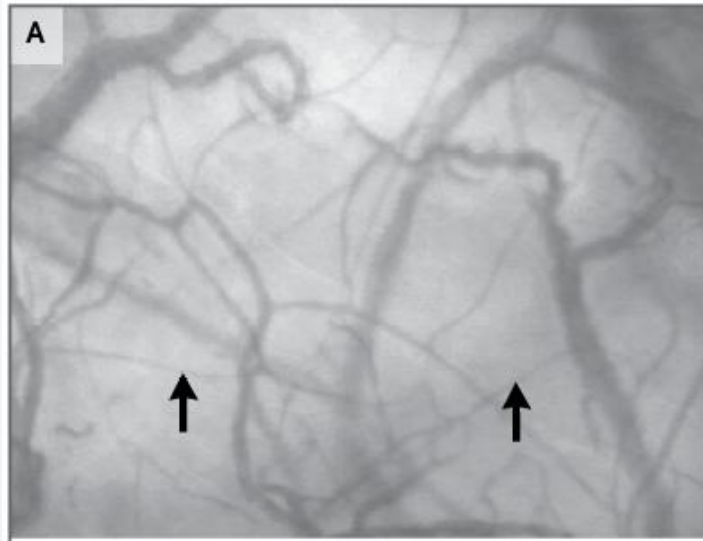
- CSF drainage during **replacement of thoracic and abdominal aorta**
- Most recommend **maintaining CSF pressure <10 mmHg (<14cmH₂O)** with continuous monitoring
- Drainage; **10-15 mL/hour**
- **Early removal** within 24 to 48 hours after surgery (in the absence of SCI)
- Anticoagulation therapy even after drain removal



Managements for Circulatory Shock (1)

- Key physiological mechanisms

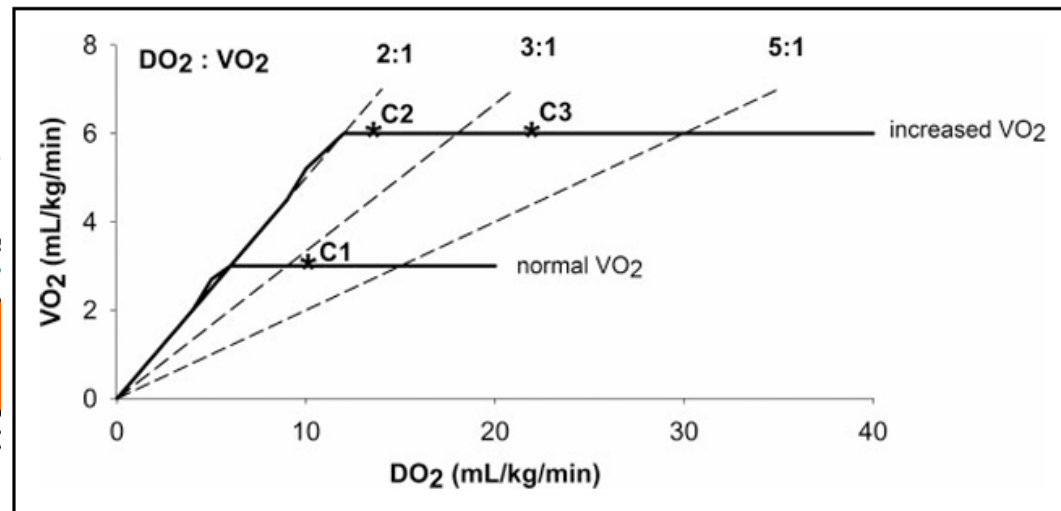
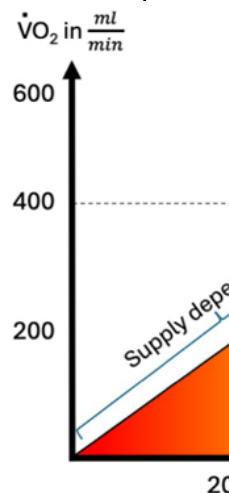
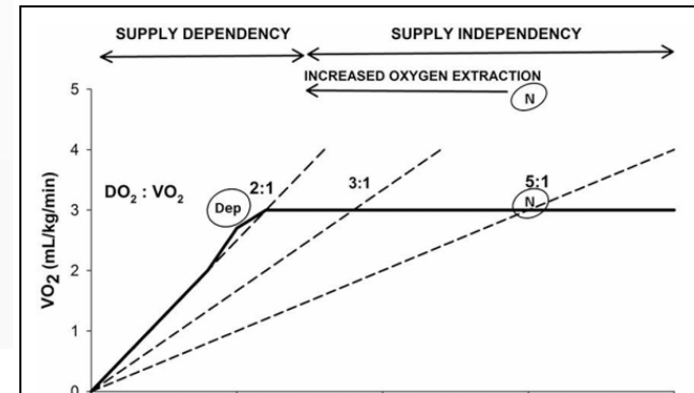
- **Sustained organ function**; adequate oxygen metabolism (**Oxygen delivery and consumption**)
- Cellular level; **sufficient oxygen delivery**, preserved mitochondrial function, effective clearance of metabolic by-products



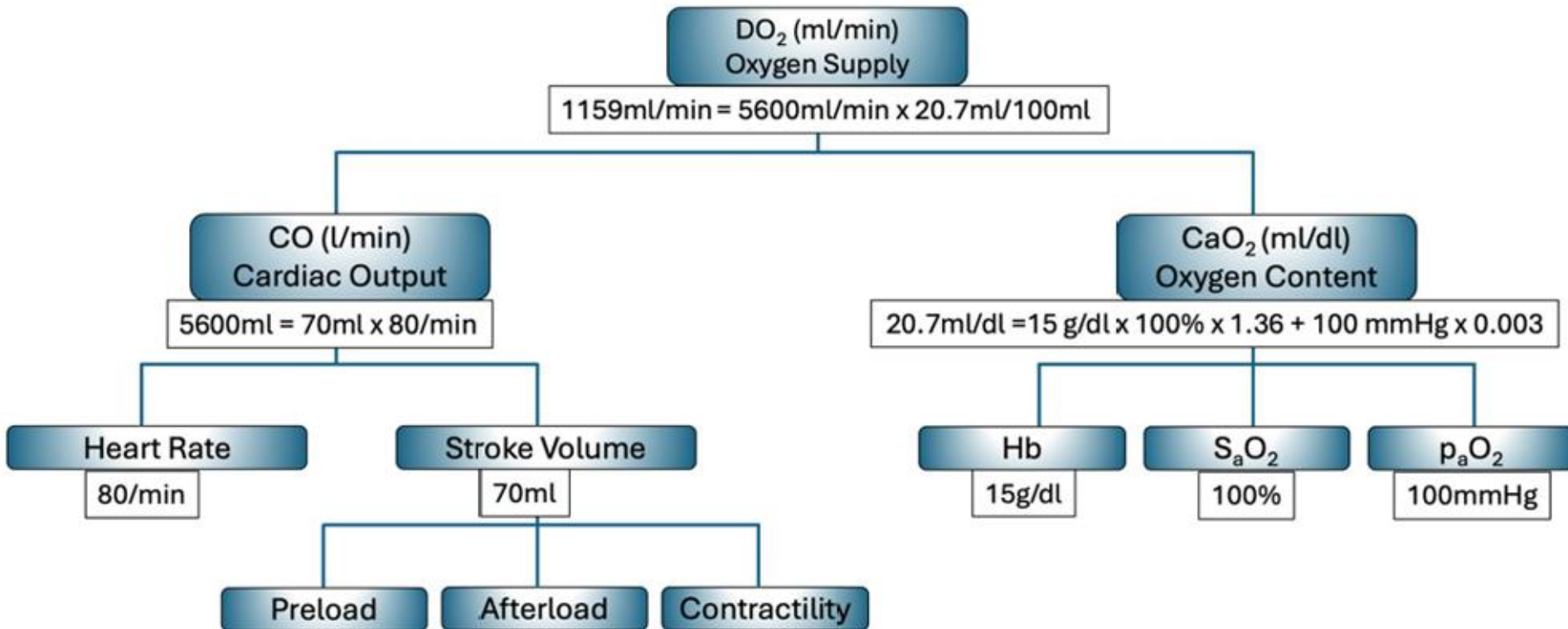
Managements for Circulatory Shock (2)

● Oxygen extraction ratio ($O_2ER = VO_2/DO_2$)

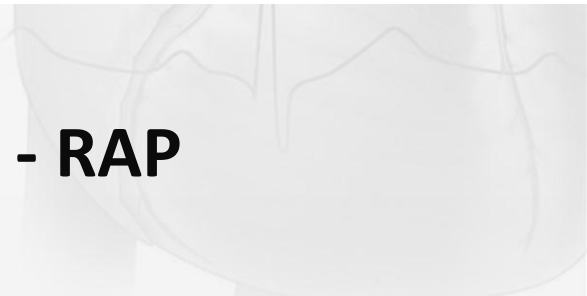
- DO_2 (Oxygen Delivery); 600 ml/min/m²
- VO_2 (Oxygen Consumption); 120 ml/min/m²
- Normal $O_2ER = 5:1$
- $DO_2 \downarrow \rightarrow O_2ER \uparrow$
- Critical DO_2 ; Supply dependent
 - Anaerobic metabolism, lactate $\uparrow$



Managements for Circulatory Shock (3)



Knock (4)



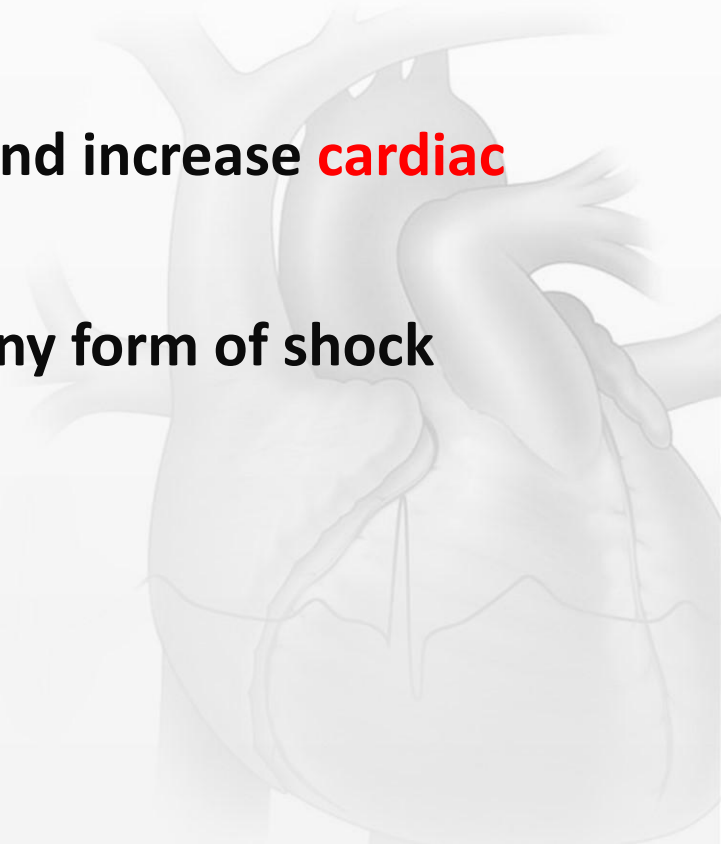
Managements for Circulatory Shock (5)

• Ventilatory support

- to increase **oxygen delivery** and prevent **pulmonary hypertension**.

• Fluid resuscitation

- to improve **microvascular blood flow** and increase **cardiac output**
- **an essential part** of the treatment of any form of shock
- **Cardiac dysfunction; acute edema**
 - fluid-challenge technique
 - Sono; IVC or lung B-line



Managements for Circulatory Shock (6)

• Vasoactive agents

▪ Vasopressors; **Norepinephrine**

- predominantly α -adrenergic properties, but its modest β -adrenergic effects
 - Pure β -adrenergic agent; isoproterenol (x)
 - Pure α -adrenergic agent; phenylephrine (x)

▪ Vasopressin;

- Vasopressin deficiency; develop in patients with very hyperkinetic forms of distributive shock
- **Low-dose vasopressin**; ≤ 0.04 IU/min

▪ Dopamine;

- β -adrenergic effects at lower doses and α -adrenergic effects at higher doses
- **more arrhythmias, increase rate of death in cardiogenic and septic shock**
- Dopaminergic stimulation; endocrine effects on the hypothalamic–pituitary system, resulting in immune suppression, primarily through a reduction in the release of prolactin
- no longer recommend dopamine for the treatment of patients with shock

Managements for Circulatory Shock (6)

• Vasoactive agents

▪ Epinephrine;

- predominantly β -adrenergic effects at low doses
- α -adrenergic effects at higher doses
- Arrhythmia, blood lactate levels, cellular metabolism $\uparrow$

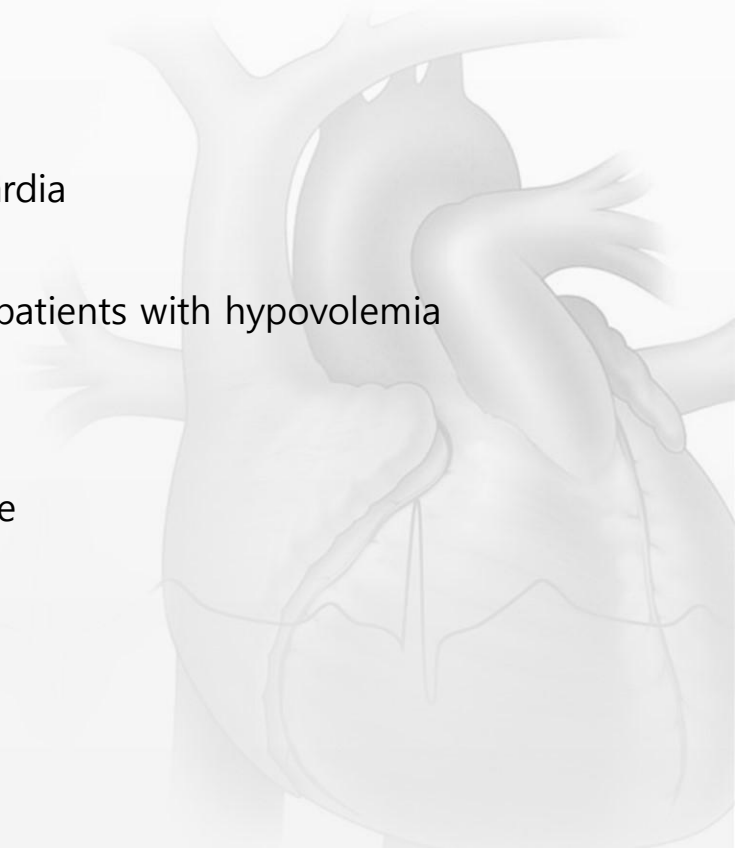
• Inotropic Agents

▪ Dobutamine;

- CO $\uparrow$, capillary perfusion $\uparrow$, less likely to induce tachycardia
- ≥ 20 $\mu\text{g/kg/min}$; provide little additional benefit
- limited effects on arterial pressure, decrease slightly in patients with hypovolemia

▪ Phosphodiesterase type III inhibitors (Milrinone);

- combine inotropic and vasodilating properties
- cAMP metabolism $\downarrow$; reinforce the effects of dobutamine
- adverse effects; hypotension,
- long half-lives of these agents (4 to 6 hours)



Managements for Circulatory Shock (7)

● Vasodilators

- Afterload↓; CO↑ without increasing myocardial O₂ demand

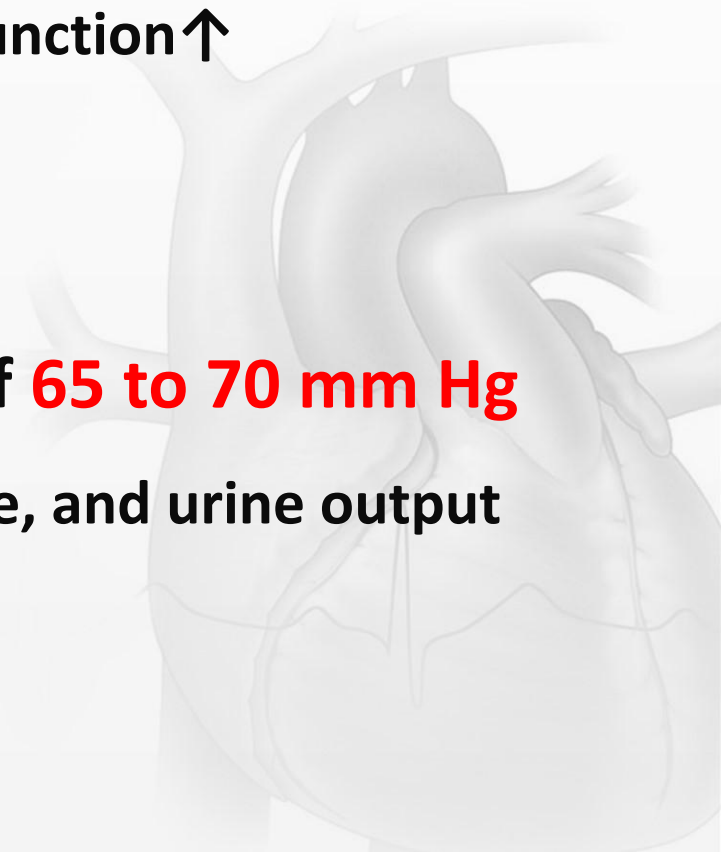
- microvascular perfusion and cellular function↑

▪ Nitrate

- risk of decreasing arterial pressure

● Mean systemic arterial pressure of 65 to 70 mm Hg

- basis of mental status, skin appearance, and urine output
- SvO₂, serum lactate level($\geq 3\text{mmol/L}$)



Managements for Circulatory Shock (8)

	Salvage	Optimization	Stabilization	De-escalation
Phase Focus	Obtain a minimal acceptable blood pressure	Provide adequate oxygen availability	Provide organ support	Wean from vasoactive agents
	Perform lifesaving measures	Optimize cardiac output, SvO ₂ , lactate	Minimize complications	Achieve a negative fluid balance

Figure 3. Four Phases in the Treatment of Shock.

The salvage phase focuses on achieving a blood pressure and cardiac output compatible with immediate survival and performing lifesaving procedures to treat the underlying cause of shock. The optimization phase focuses on promoting cellular oxygen availability and monitoring cardiac output, mixed venous oxygen saturation (SvO₂), and lactate levels. The stabilization phase focuses on preventing organ dysfunction, even after hemodynamic stability has been achieved. The de-escalation phase focuses on weaning the patient from vasoactive agents and providing treatments to help achieve a negative fluid balance.

Thank You for Your Attention

