Disordersoffluid balanceinICU patients

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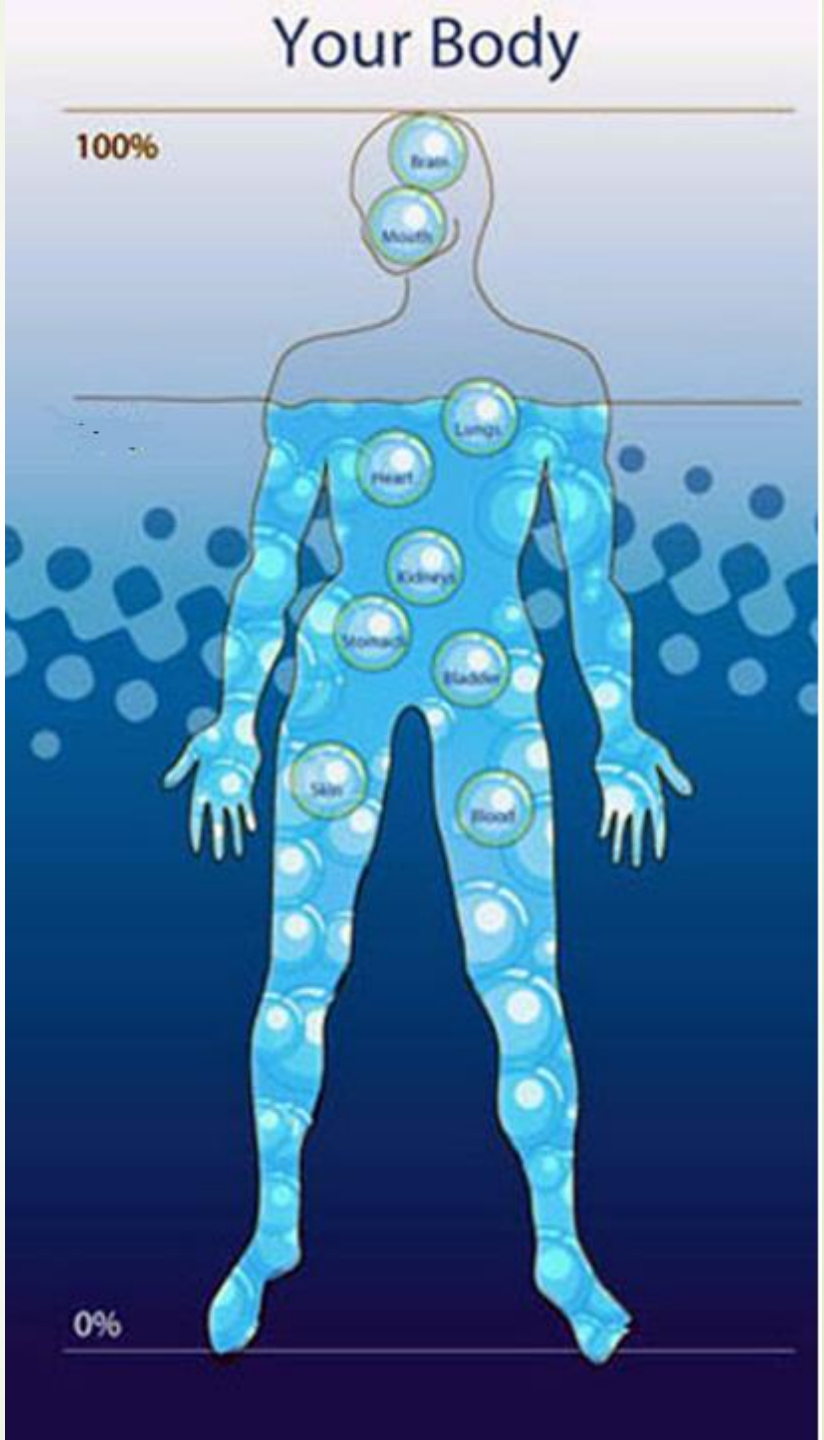
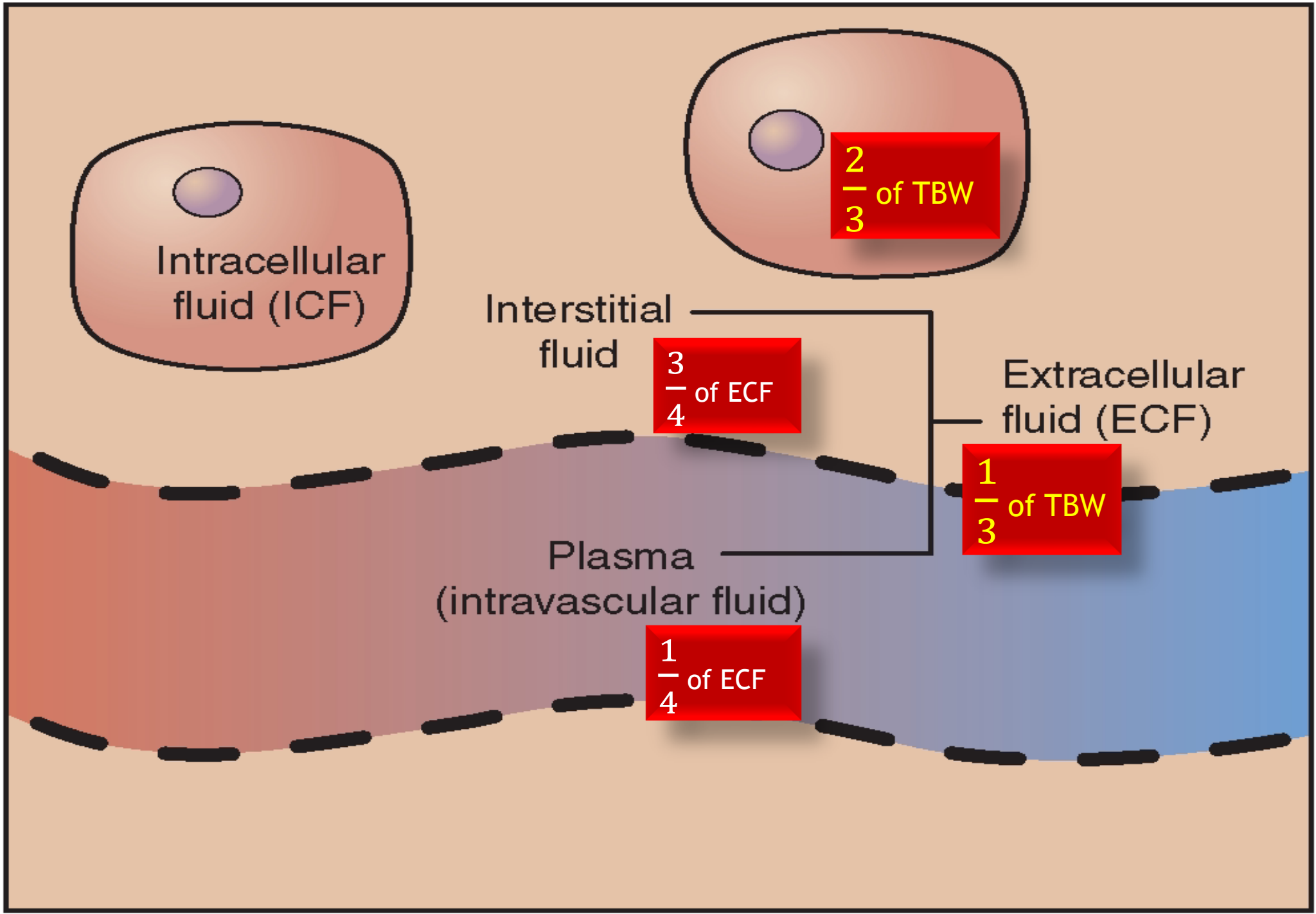
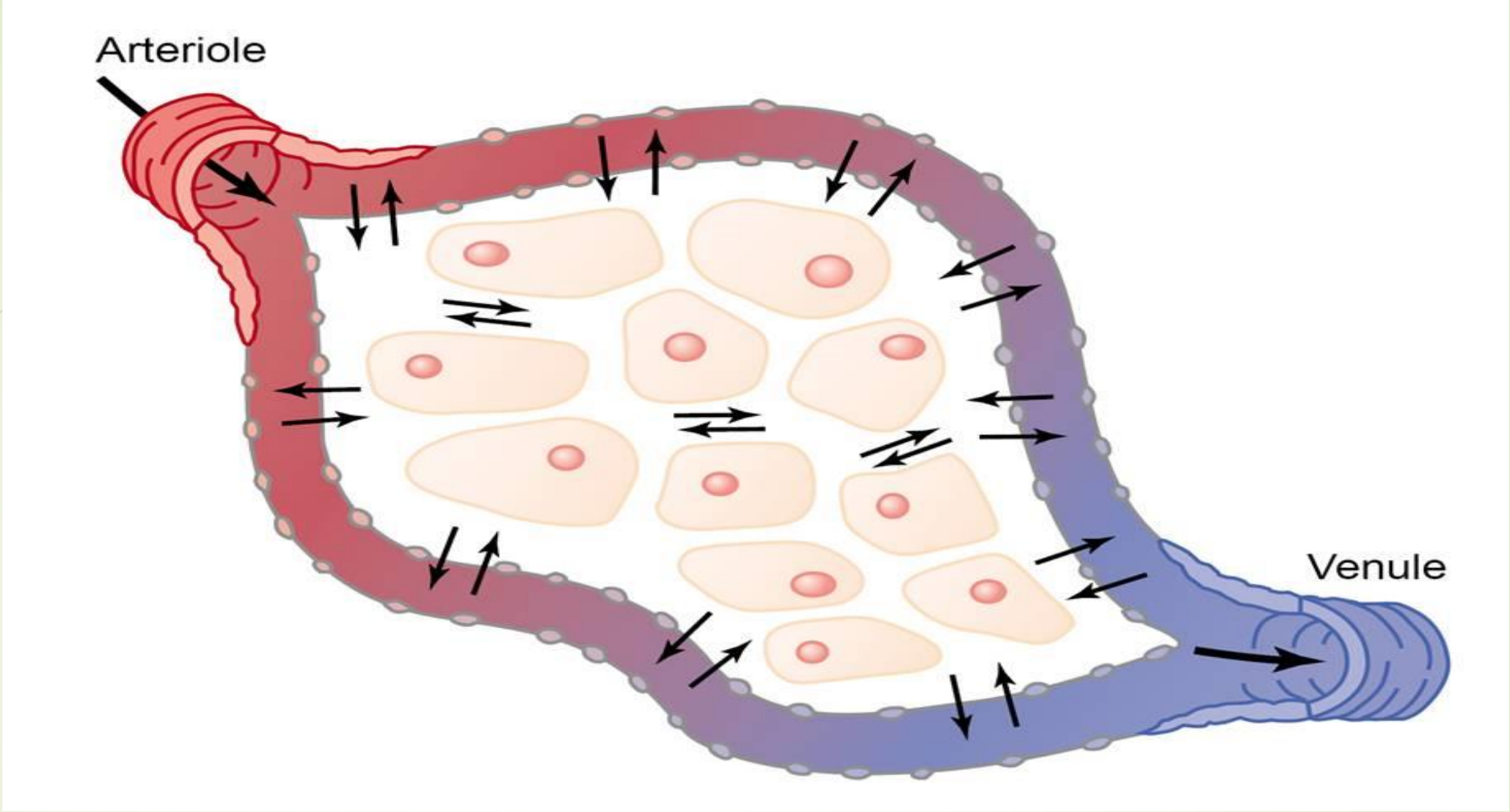
COMPOSITION OF BODY FLUIDS


The most abundant constituent in the body

- **50% of body weight in woman**
- **60% of body weight in man**



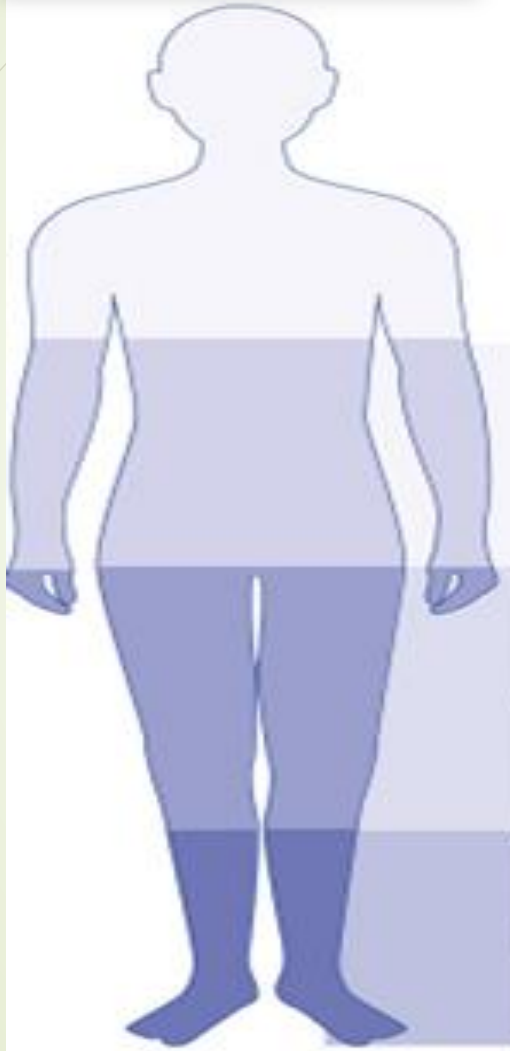

Intracellular fluid (ICF)
2/3 of TBW
Interstitial fluid
3/4 of ECF
Extracellular fluid (ECF)
1/3 of TBW
Plasma (intravascular fluid)
1/4 of ECF



- Oncotic pressure: Proteins specially albumin
- Hydrostatic pressure: Cardiac cotracture

A 70 kg man

Intracellular Water (2/3)		Extracellular Water (1/3)	
		Interstitial (2/3)	Blood (1/3)
25	Na	140	
150	K	4.5	
15	Mg	1.2	
0.01	Ca	2.4	
2	Cl	100	
6	HCO_3	25	
50	Phos	1.2	



ICF= 2/3 TBW (28 L)

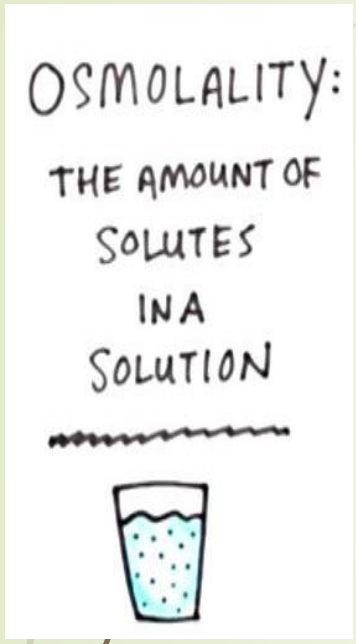
ISF= 3/4 ECF (10.5 L)

ECF= 1/3 TBW (14 L)

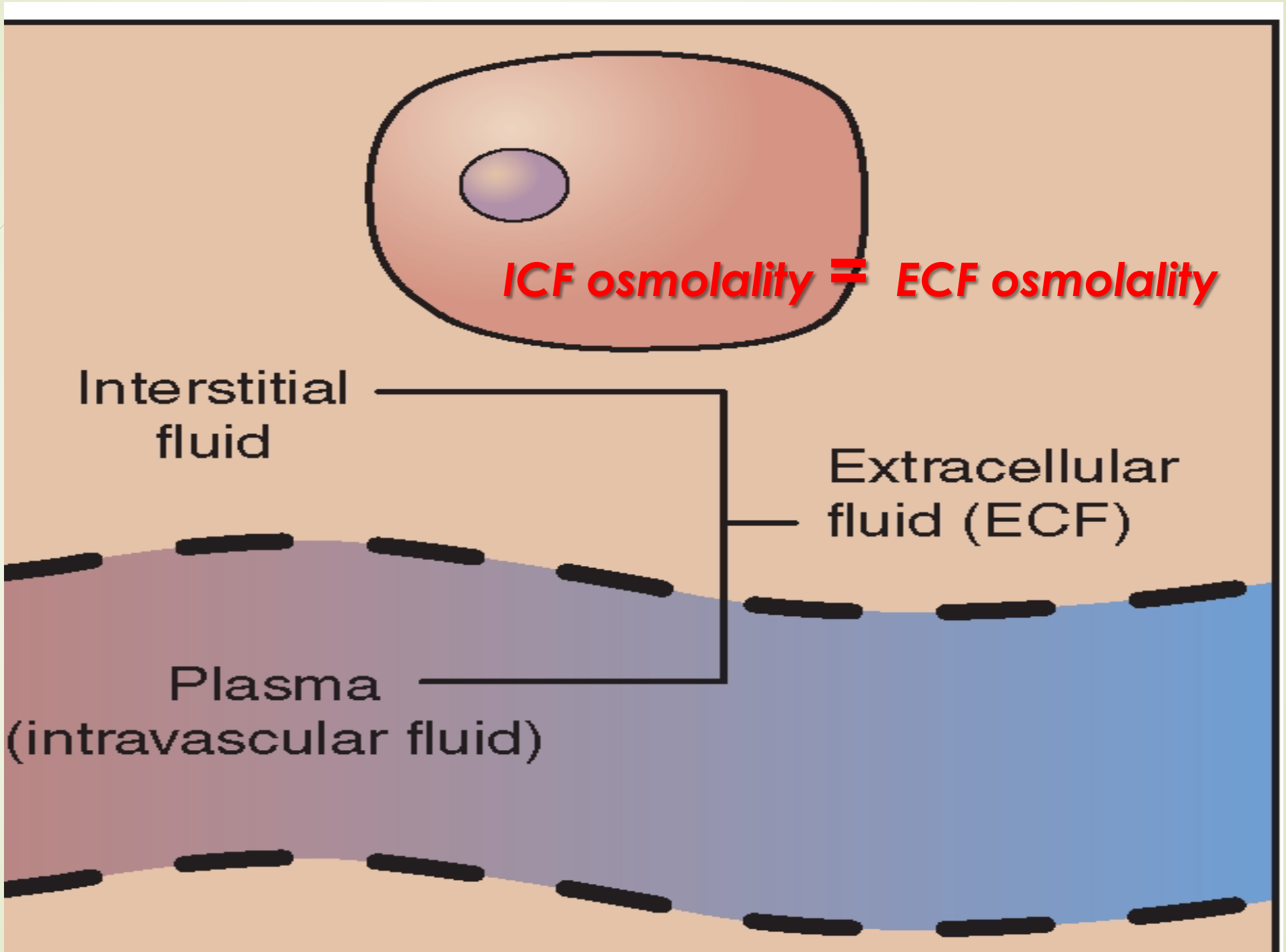
TWB= 60% weight (42 L)

IVF= 1/4 ECF (3.5 L)

- Osmolality?
- Osmolarity?
- Tonicity?



- **Osmolality=** TOTAL NO. OF SOLUTE PARTICLES PER **KG** OF A FLUID (**MOSM/KG**)
- **Osmolarity=** TOTAL NO. OF SOLUTE PARTICLES PER **LITER** OF A FLUID(**MOSM/L**)
- **Tonicity=** EFFECTIVE PLASMA OSMOLALITY


ICF osmolality = ECF osmolality
Interstitial fluid
Extracellular fluid (ECF)
Plasma (intravascular fluid)

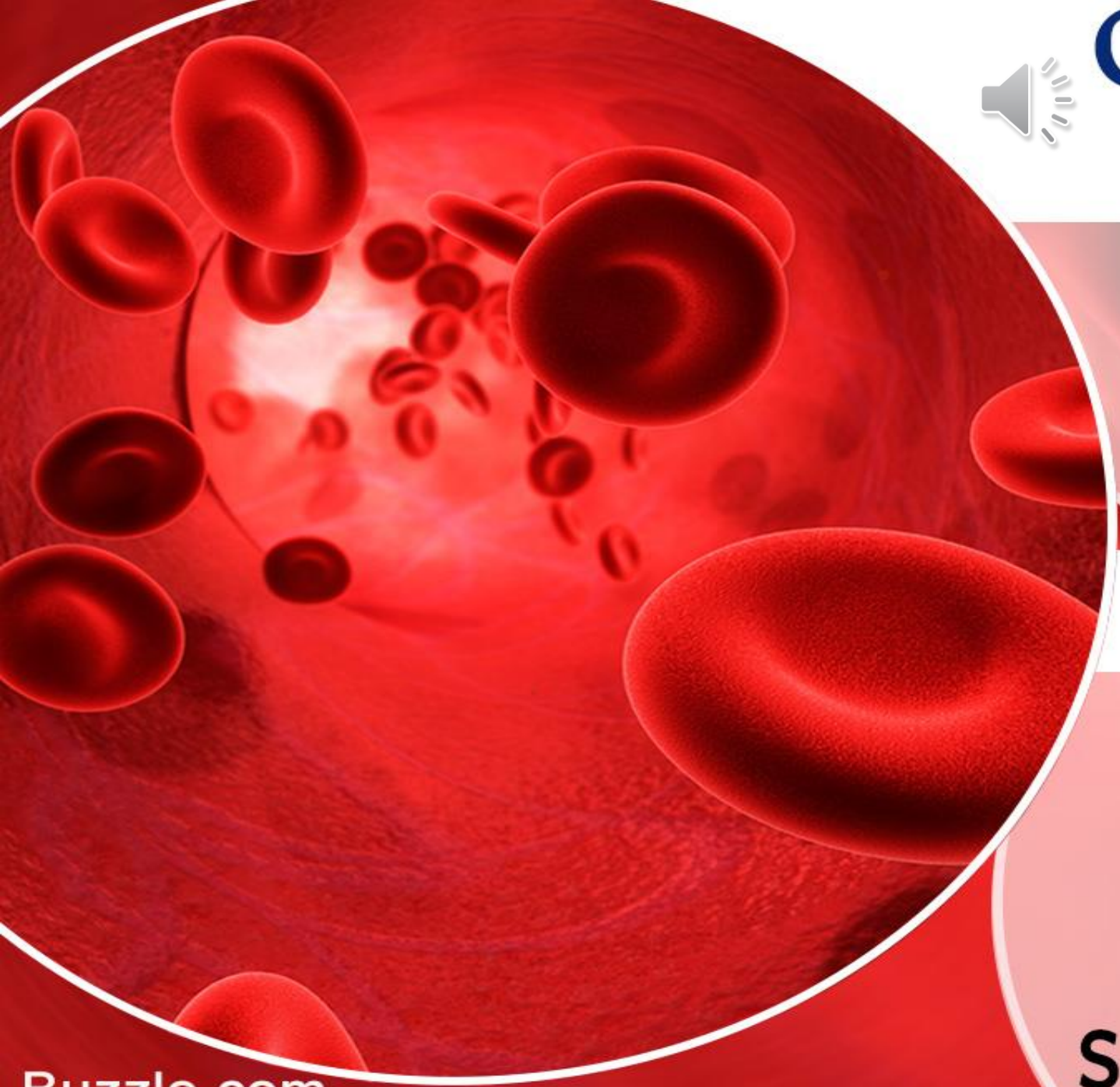
Plasma osmolality

Unit of measurement?

$$milliosmol/kg$$

$$\textit{Plasma osmolality} = 2 \times Na + \frac{Glucose}{18} + \frac{BUN}{2.8}$$

The normal plasma osmolality is 280 to 295 mosmol/kg.



Osmolarity and Osmolality

Total solute concentrations.

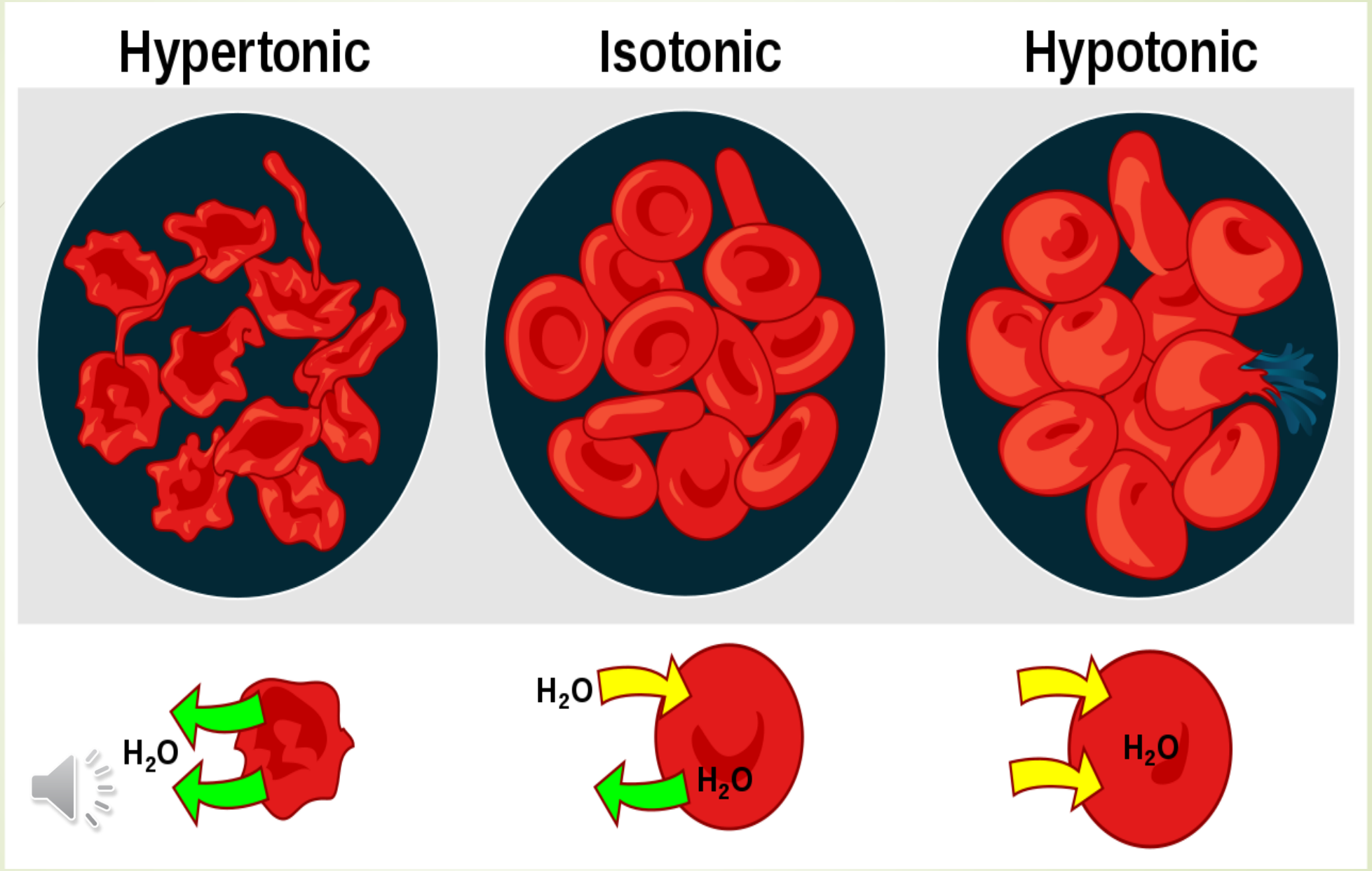
Tonicity

Concentration of only impermeable solute particles.

Effective Osmolality

- Solutes that are restricted to the ECF or the ICF determine the *effective osmolality* (or *tonicity*) of that compartment.

- Certain solutes, such as urea, do not contribute to water shift across cell membranes and are known as *ineffective osmoles*.

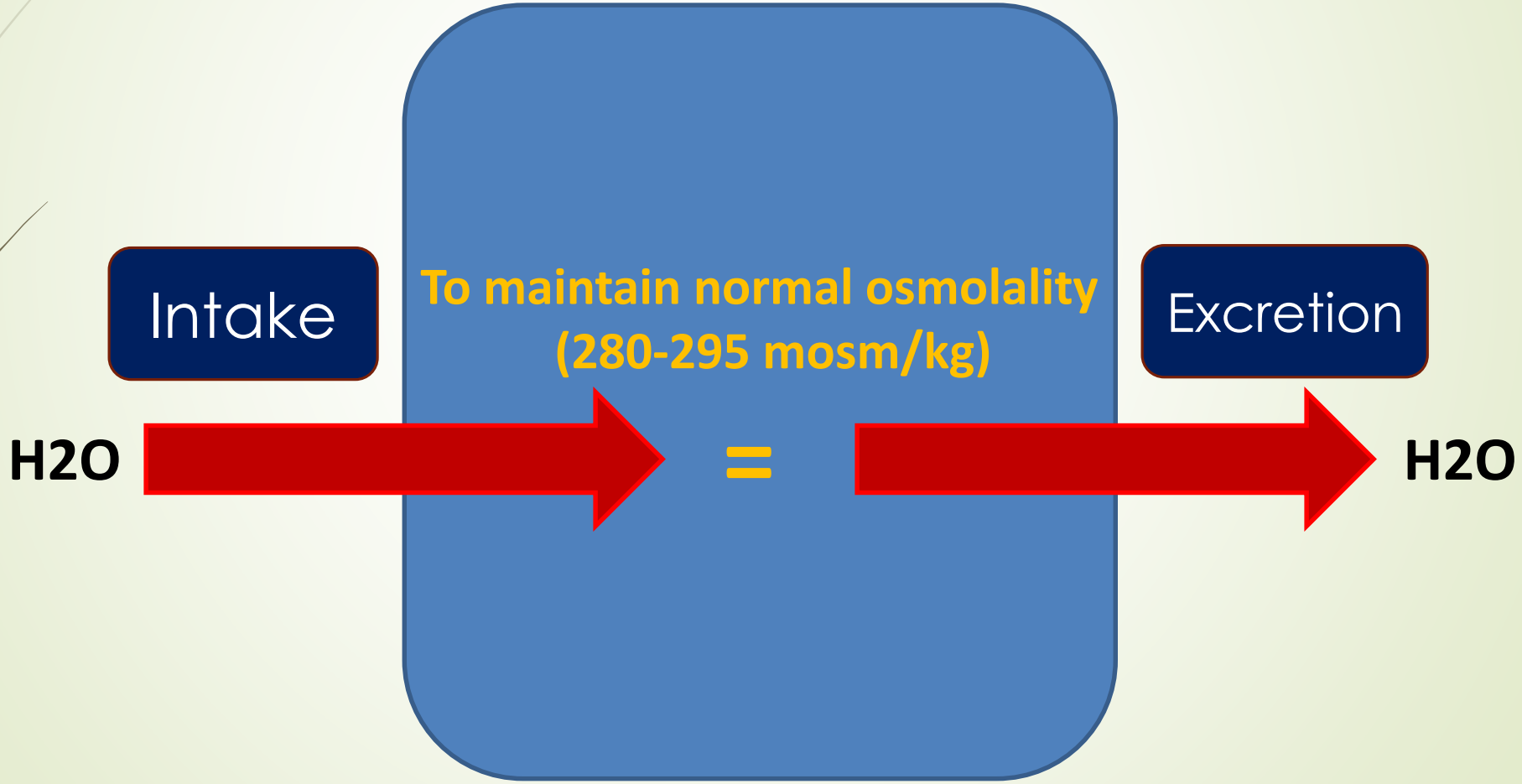

Hypertonic
Isotonic
Hypotonic
H_2O
H_2O
H_2O
H_2O
H_2O

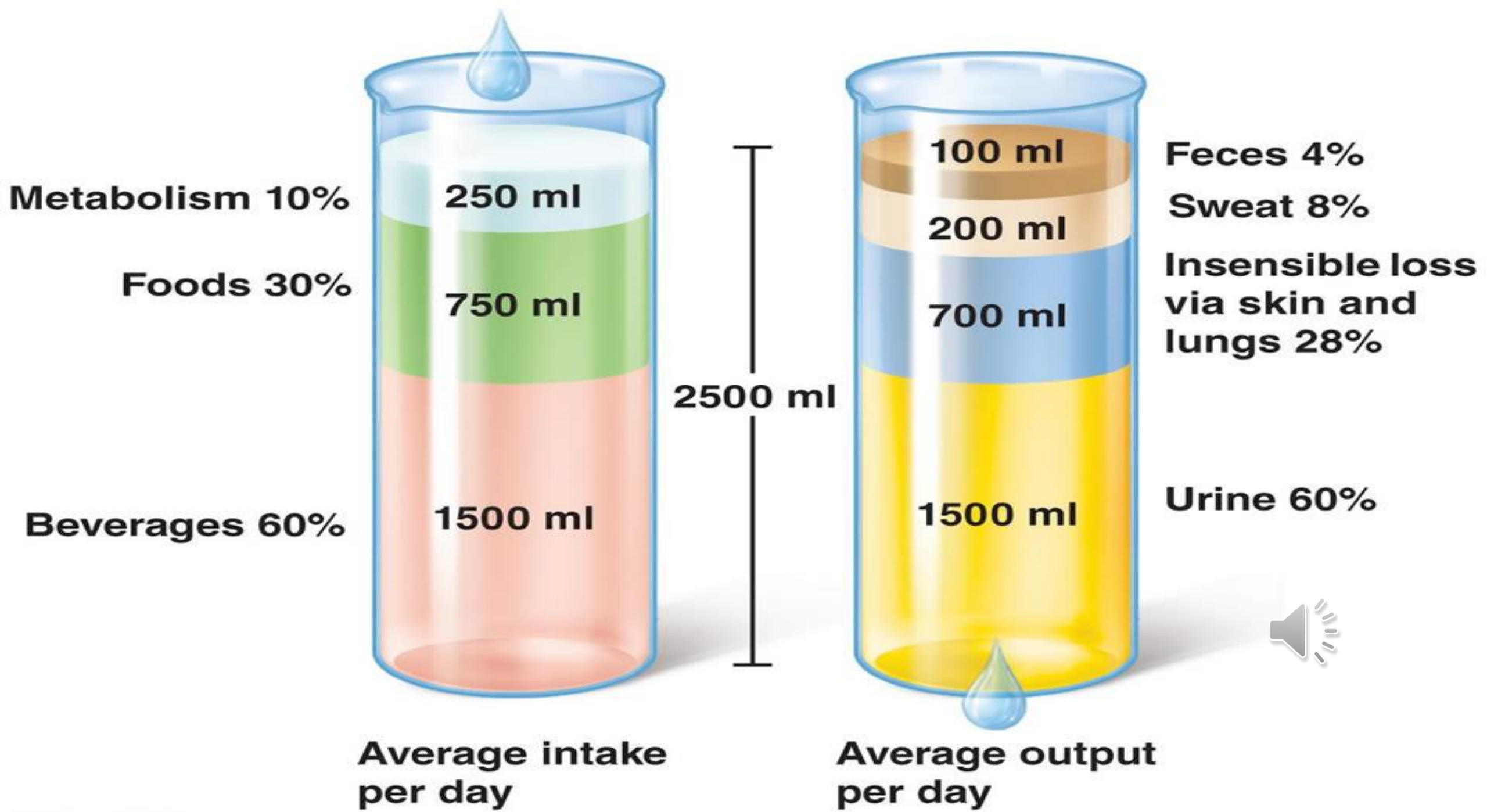

Water Balance

WATER BALANCE

- The normal plasma osmolality is 280–295 mosmol/kg and is kept within a narrow range by mechanisms capable of sensing a 1–2% change in tonicity.
- To maintain a steady state, water intake must equal water excretion.
- Disorders of water homeostasis result in hypo- or hypernatremia.

WATER BALANCE





Water Intake

- The primary stimulus for water ingestion is *thirst*, mediated either by an *increase in effective osmolality* or a *decrease in ECF volume or blood pressure.*

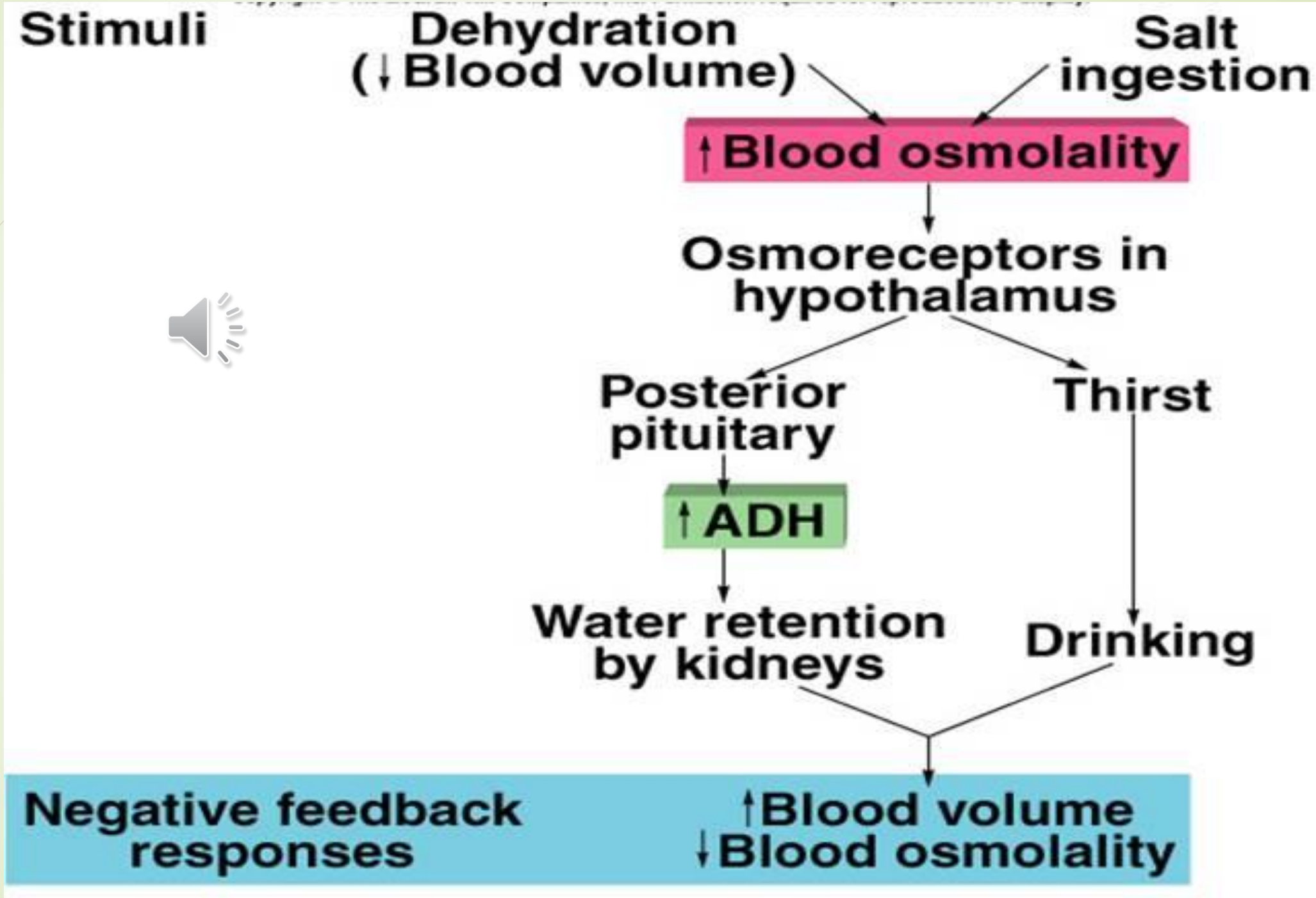
- *Osmoreceptors*, located in the anterolateral hypothalamus, are stimulated by a rise in tonicity.

Differences between osmoregulation and volume regulation

	Osmoregulation	Volume regulation
What is being sensed	Plasma osmolality	Effective circulating volume
Sensors	Hypothalamic osmoreceptors	Carotid sinus
		Afferent glomerular arteriole
		Atria
Effectors	ADH	Sympathetic nervous system
		Renin-angiotensin-aldosterone
		Natriuretic peptides
		Pressure natriuresis
		ADH
What is affected	Water excretion (via ADH)	Sodium excretion
	Water intake (via thirst)	

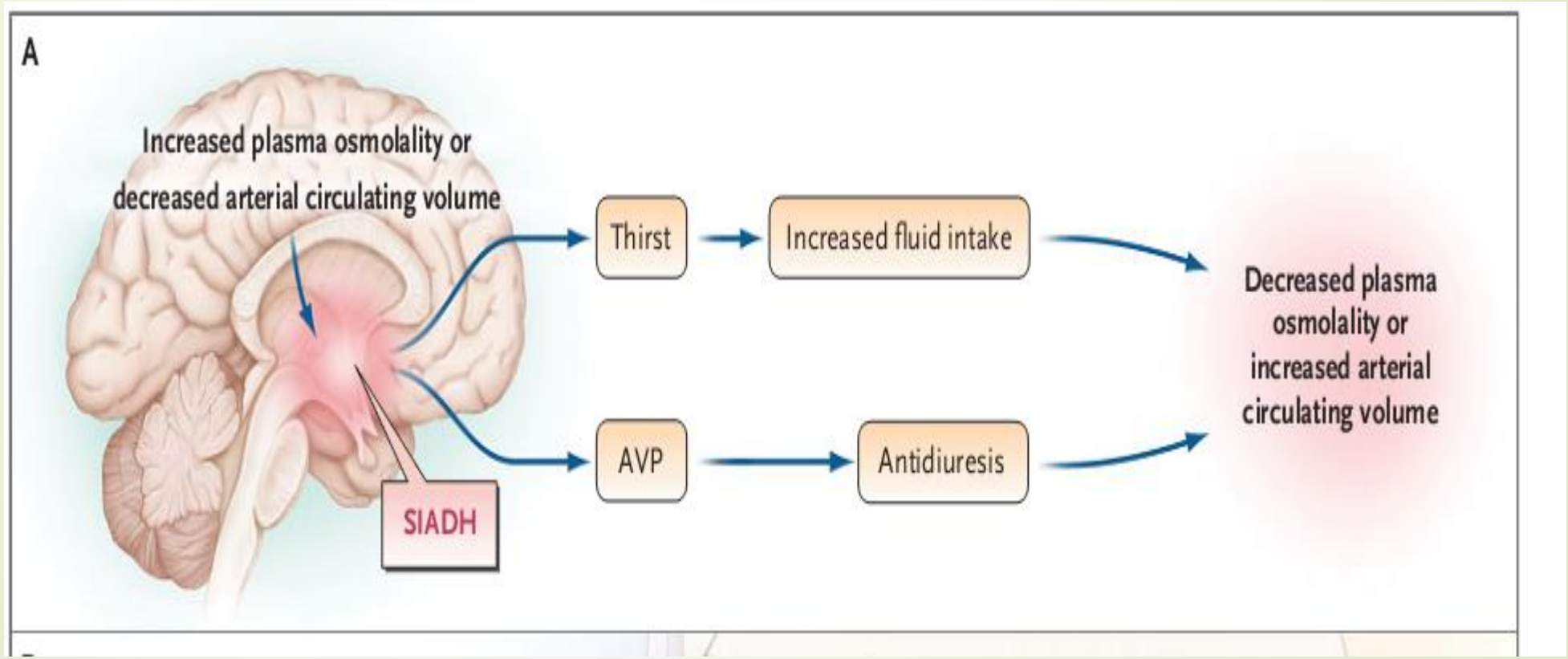
Water Intake

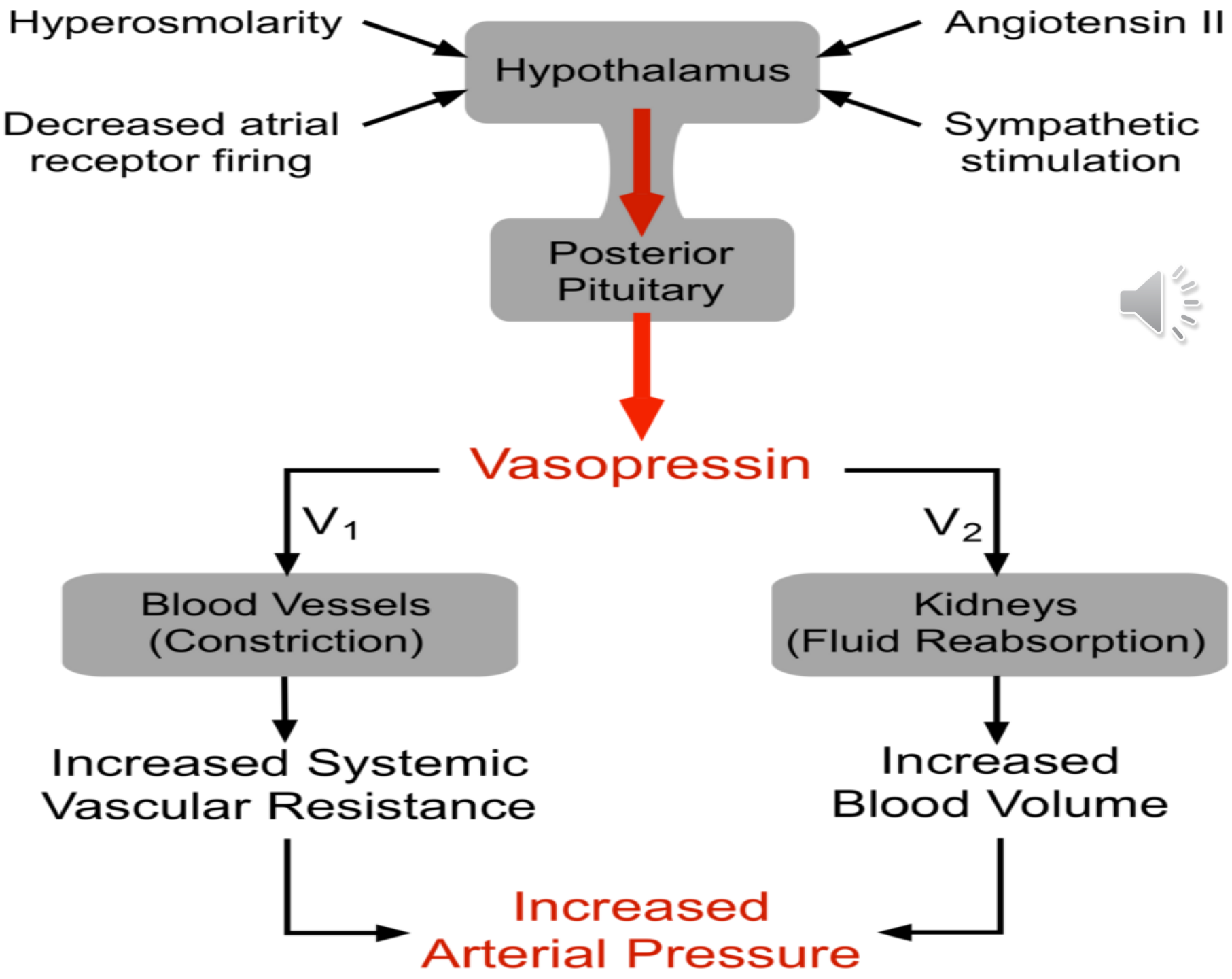
- Ineffective osmoles, such as urea, do not play a role in stimulating thirst.
- The average osmotic threshold for thirst is approximately 285 mosmol/kg and varies among individuals.


Stimuli
Dehydration
(↓Blood volume)
Salt
ingestion
↑Blood osmolality
Osmoreceptors in
hypothalamus
Posterior
pituitary
Thirst
↑ADH
Water retention
by kidneys
Drinking
Negative feedback
responses
↑Blood volume
↓Blood osmolality

Water Excretion

- The principal determinant of renal water excretion is *arginine vasopressin* (**AVP**; formerly antidiuretic hormone=ADH).




Hyperosmolarity
Decreased atrial receptor firing
Hypothalamus
Angiotensin II
Sympathetic stimulation
Posterior Pituitary
Vasopressin
V1
V2
Blood Vessels (Constriction)
Kidneys (Fluid Reabsorption)
Increased Systemic Vascular Resistance
Increased Blood Volume
Increased Arterial Pressure

Stimulus for AVP secretion

- **Hypertonicity:**
  - The osmotic threshold for AVP release is 285 mosmol/kg, and the system is sufficiently sensitive that plasma osmolality varies by no more than 1–2%.

- **Nonosmotic factors :**
  - *Effective circulating (arterial) volume*
  - nausea, pain, stress, hypoglycemia, pregnancy, and numerous drugs.

- ECF (Extracellular fluid)

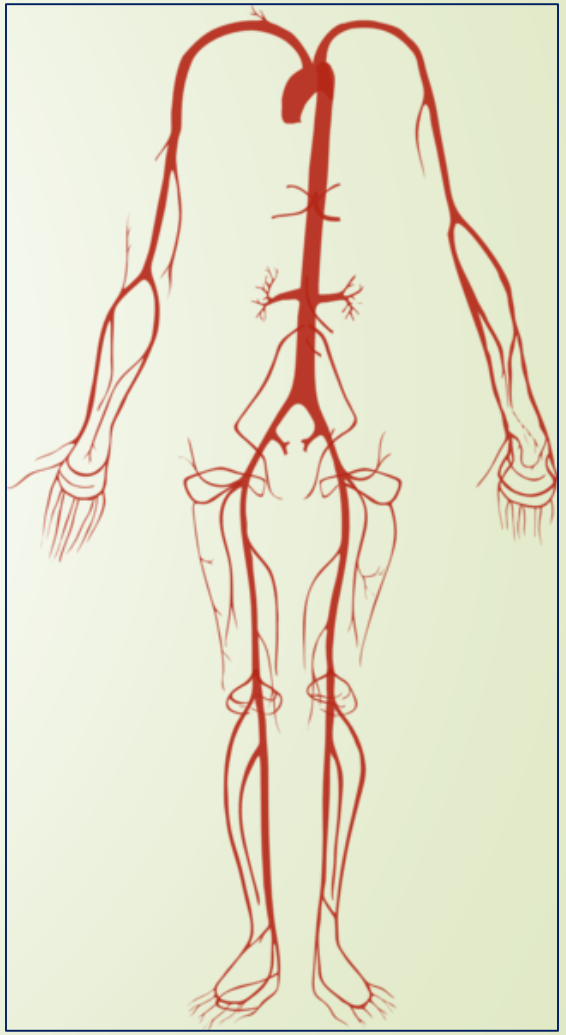
VS

- ECV (Effective circulating vol.)

?

Effective circulating volume

- Refers to that part of the extracellular fluid (ECF) that is in the arterial system and is effectively perfusing the tissues.

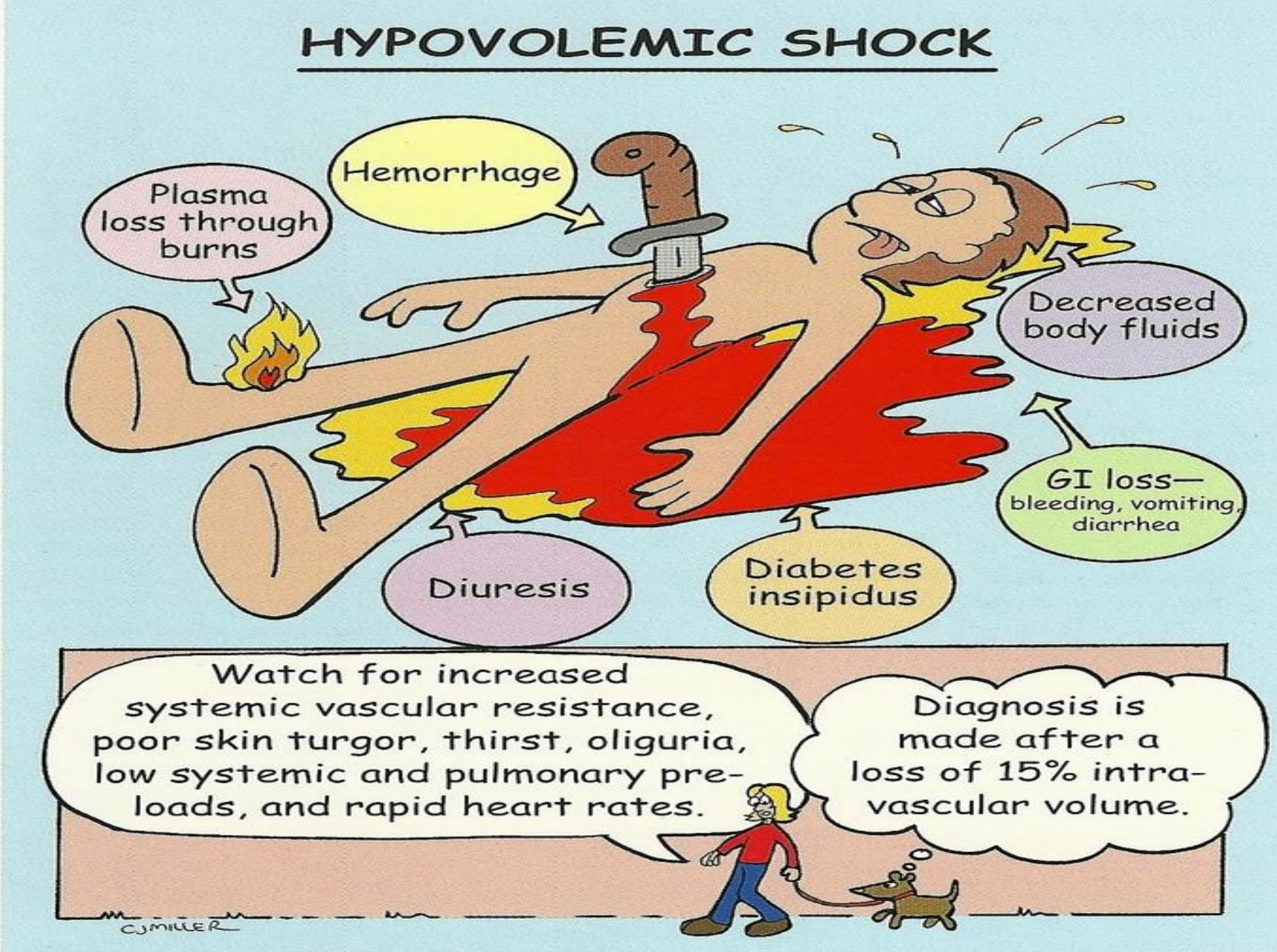


Potential independence of effective arterial blood volume from other hemodynamic measur

Clinical condition	Effective volume	Extracellular volume
True volume depletion	Decreased	Decreased
Heart failure	Decreased	Increased
Advanced cirrhosis	Decreased	Increased

Abnormalities in plasma tonicity and the extracellular volume lead to the following four basic disorders of water and sodium balance:

- Hyponatremia (too much water)
- Hypernatremia (too little water)
- Hypovolemia (too little sodium, the main extracellular solute)
- Edema (too much sodium with associated water retention)


HYPOVOLEMIC SHOCK
Plasma loss through burns
Hemorrhage
Decreased body fluids
GI loss— bleeding, vomiting, diarrhea
Diuresis
Diabetes insipidus
Watch for increased systemic vascular resistance, poor skin turgor, thirst, oliguria, low systemic and pulmonary pre-loads, and rapid heart rates.
Diagnosis is made after a loss of 15% intra-vascular volume.
CJMILLER

Hypovolemia ➨Etiology

➨Renal Causes:

Osmotic diuresis/Diuretics/Hypoaldosteronism/Tubulopathy/DI

➨Extrarenal Causes:

GI , Skin and Respiratory loss/Third space

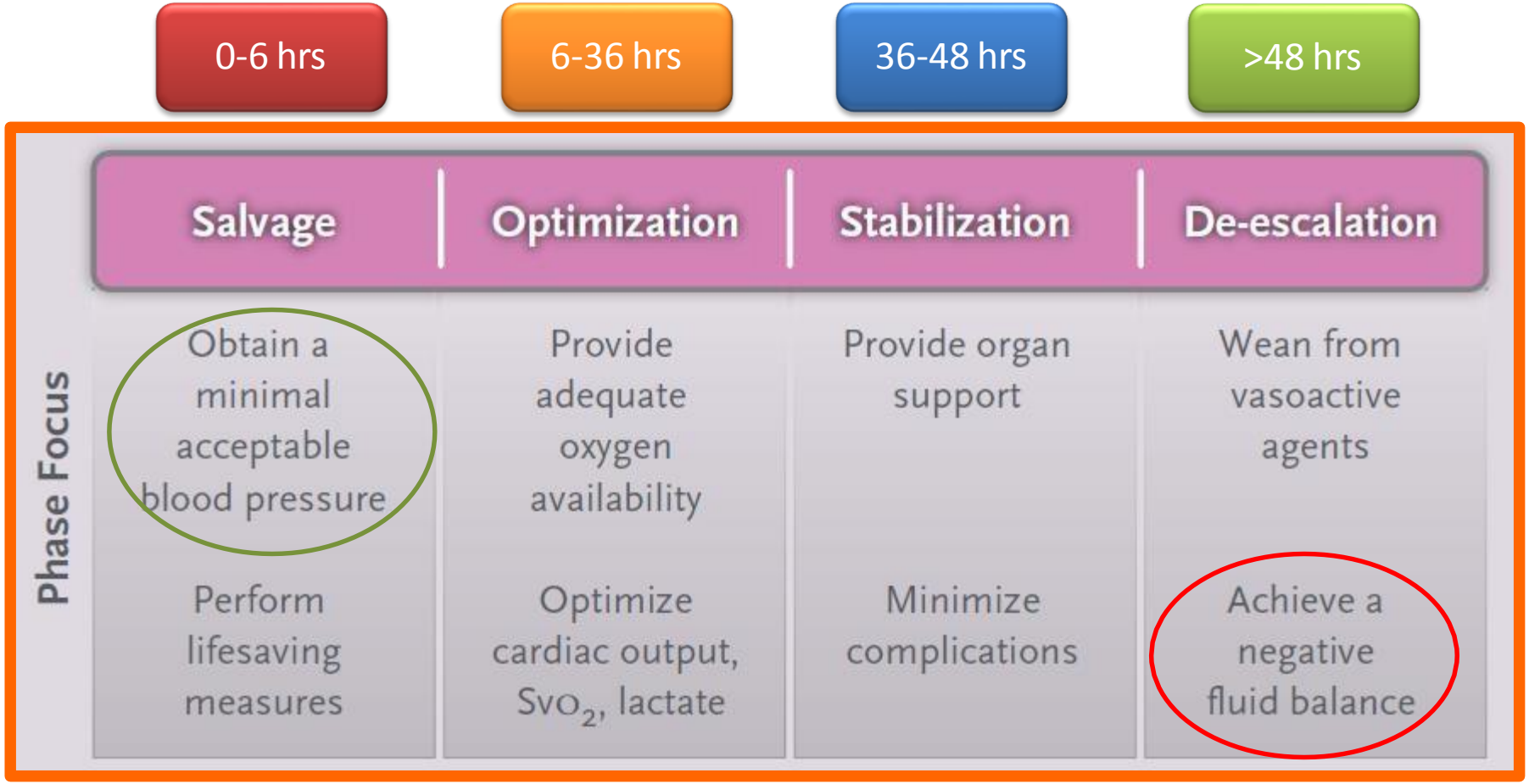
Hypovolemia

- **Evaluation:**
  - **History & P/E**: ↓ JVP/Orthostatic Tach. & Hypotension
  - **Lab:** ↑ BUN,Cr/Acid-base imbalance,……..
- **Rx**
  - Mild:Oral thrapy
  - Sever:NaCl 0.9%

Volume overload

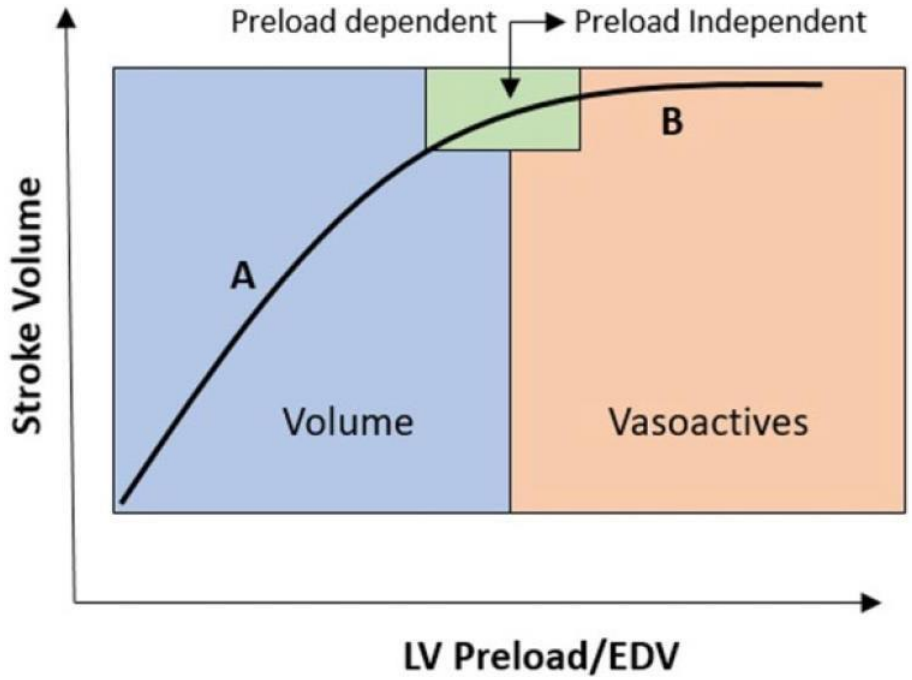
Treatment of Shock

4 phases



Vincent JL. N Engl J Med 2013;369:1726

Volume Optimization: a Clinical Challenge



The transition point from volume resuscitation to vasopressor support in treatment for sustained hypotension

Jaffee W. J Intensive Care Med 2018; 33: 502

Assessment of Volume Status

- Physical exam:
  vital signs, perfusion, [POCUS]
- Lab studies:
  lactate, BNP
- Diagnostic maneuvers:
  passive straight-leg raise, IVF challenge
- Non-invasive monitoring:
  lung U/S, IVC U/S, PPV, SVV, RBV/Hct
- Invasive monitoring:
  CO, PCWP

There is no Consensus Approach

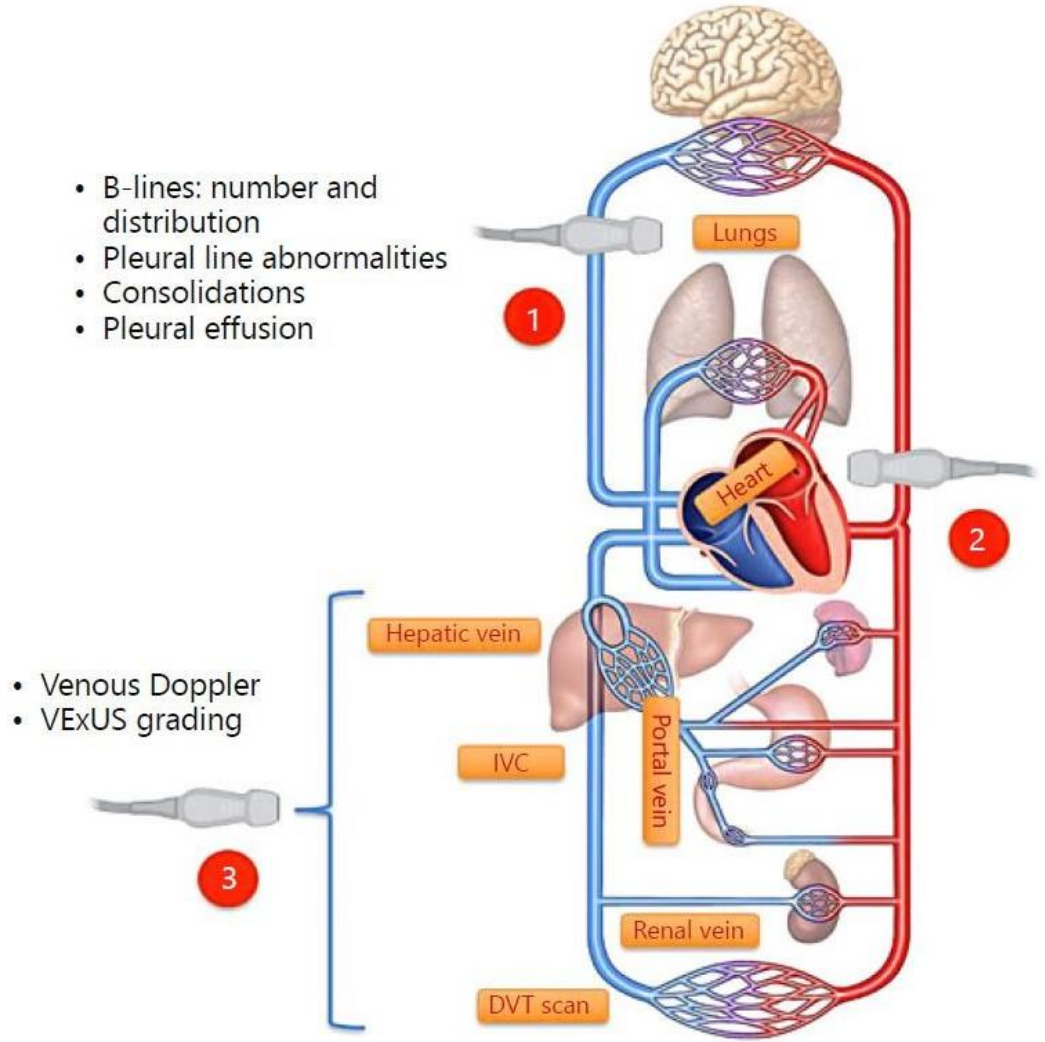
Assessment of Volume Status

Method	Invasive or noninvasive	Static or dynamic	Assess fluid responsiveness	Comments
Historical findings	Noninvasive	Static	No	Of limited value with poor correlation with invasive pressure measurements
Physical exam	Noninvasive	Static and dynamic	Yes	Of limited value but serial examinations may detect changes in organ perfusion
Chest radiograph	Noninvasive	Static	No	Requires use of standardized measures of vascular pedicle width and cardiothoracic ratio. Serial chest X-ray may be helpful in determining effects of fluid therapy
Central venous pressure	Invasive	Static	No	Poor correlation with fluid responsiveness
Pulmonary capillary wedge pressure	Invasive	Static	No	Poor correlation with fluid responsiveness
Echocardiogram	Noninvasive	Static	No	Single measures of cardiac chamber volume hard to assess. Serial measures may be helpful
Stroke volume or pulse pressure variation	Invasive (pulse oximeter method in noninvasive)	Dynamic	Yes	Requires sedated, mechanically ventilated patient
Esophageal doppler	Invasive	Dynamic	Yes	Not useful for continuous measurements
Vena cava diameter	Noninvasive	Dynamic	Yes	Body habitus dependent
Passive leg raising	Noninvasive (bioreactance end-tidal CO_2) Invasive (FloTrac or PiCCO or LiDCO)	Dynamic	Yes	Unreliable with intra-abdominal hypertension
End-expiratory occlusion	Passive leg raising	Dynamic	Yes	Requires 15-s end-expiratory occlusion
Bioimpedance	Noninvasive	Static	No	Not able to assess intravascular volume

Key Concept: Fluid Responsiveness

Kalantari K. Kidney Int 2013; 83: 1017

Assessment of Volume Status



The Tri-POCUS Approach

- Pericardial effusion
- Left ventricular ejection
- Right ventricular relative size
- PLR and stroke volume assessment
- IVC collapsibility

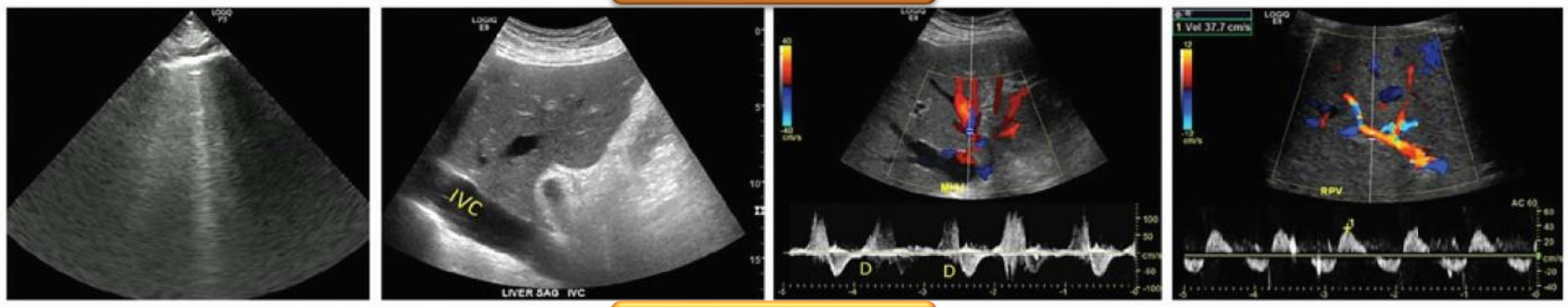
1) Lung U/S
2) Focused Cardiac U/S
3) Venous Doppler

Koratala A. Cardiorenal Med 2020

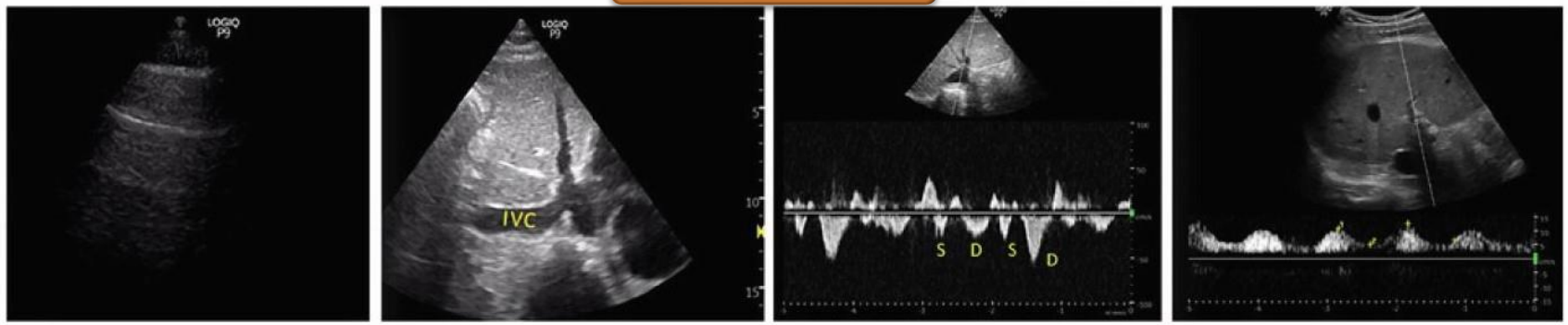
Assessment of Volume Status

The Tri-POCUS Approach

At Presentation



After Decongestion



LUS
Right lateral zone is shown

IVC ultrasound

Heptic vein Doppler

Portal vein Doppler

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Fluid Balance and Mortality

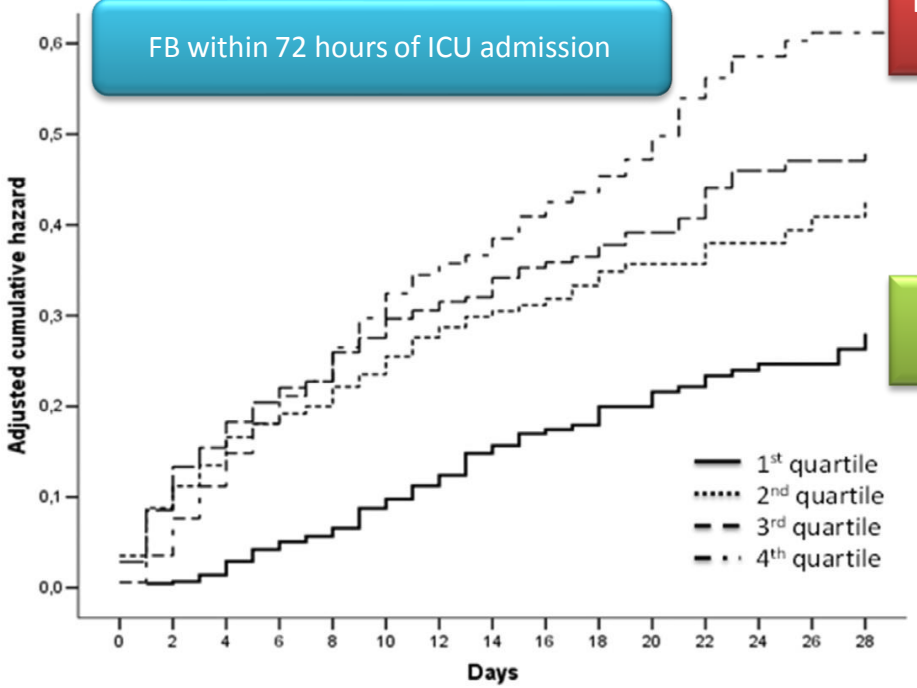
28-day in-hospital death

1,808 patients

FB within 72 hours of ICU admission

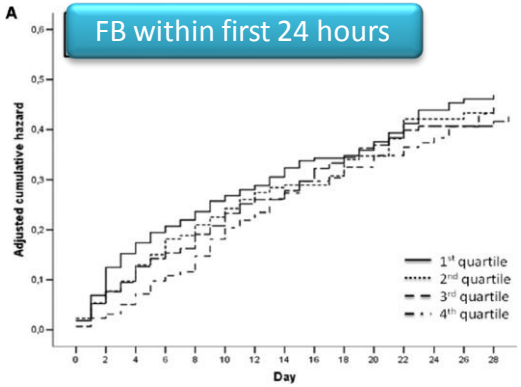
Highest FB

Lowest FB



A

FB within first 24 hours

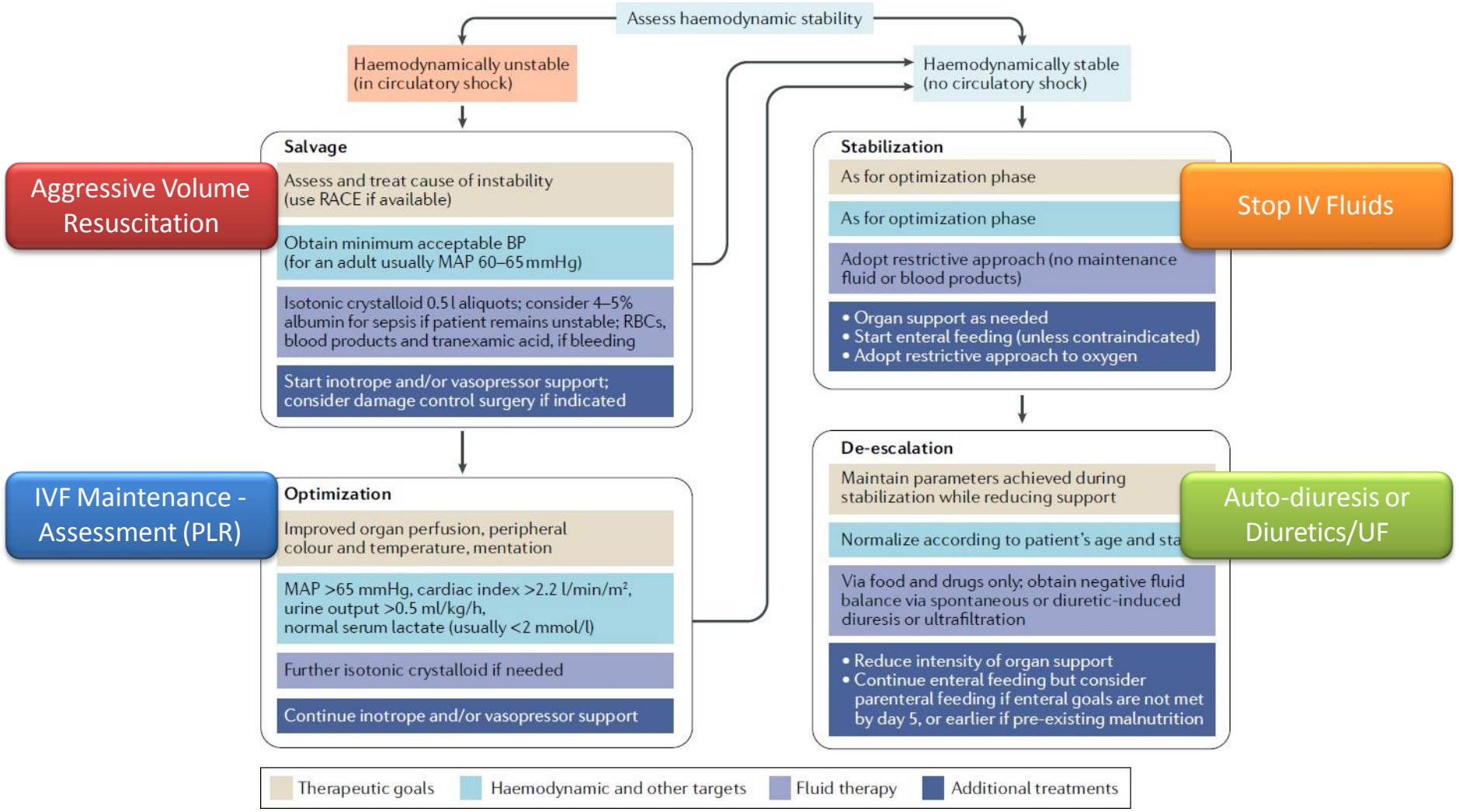


Higher cumulative fluid balance at day 3 (but not in the first 24 hours); higher mortality

Sakr Y. Crit Care Med 2017; 45:386

Fluid Management in Shock

4 phases



Aggressive Volume Resuscitation

IVF Maintenance - Assessment (PLR)

Stop IV Fluids

Auto-diuresis or Diuretics/UF

Finfer S. Nature Rev 2018;14:541

Fluid Management Guidelines

Fluid Stewardship

UF UNIVERSITY of FLORIDA

Malbrain M. ICU management and Practice 2020; 20: 6