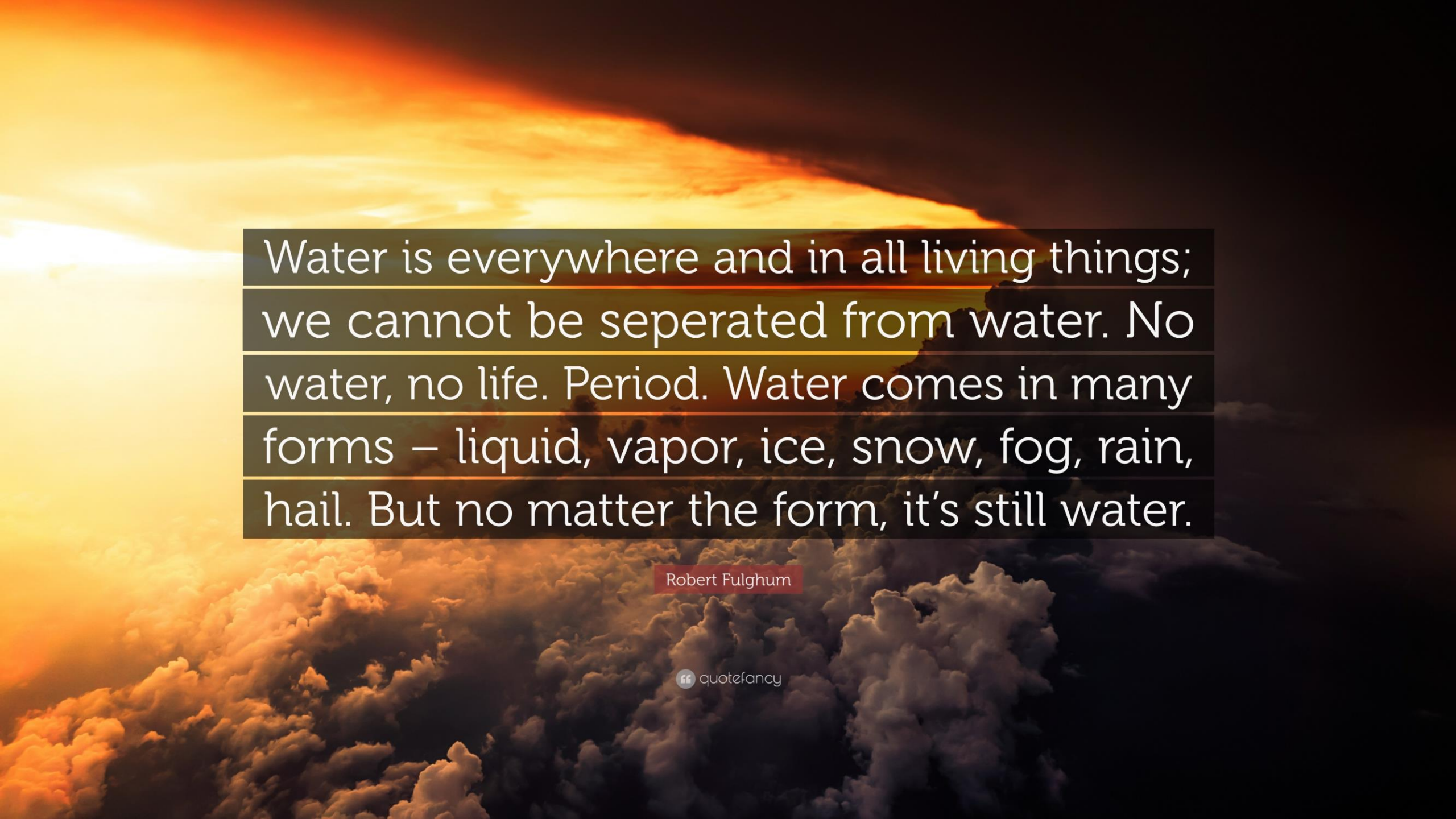


Infusion therapy. Parenteral nutrition.

MD, PhD, Kirill Lobastov





Water is everywhere and in all living things;
we cannot be seperated from water. No
water, no life. Period. Water comes in many
forms – liquid, vapor, ice, snow, fog, rain,
hail. But no matter the form, it's still water.

Robert Fulghum

quote fancy

How much we consist of water?

60%



80%

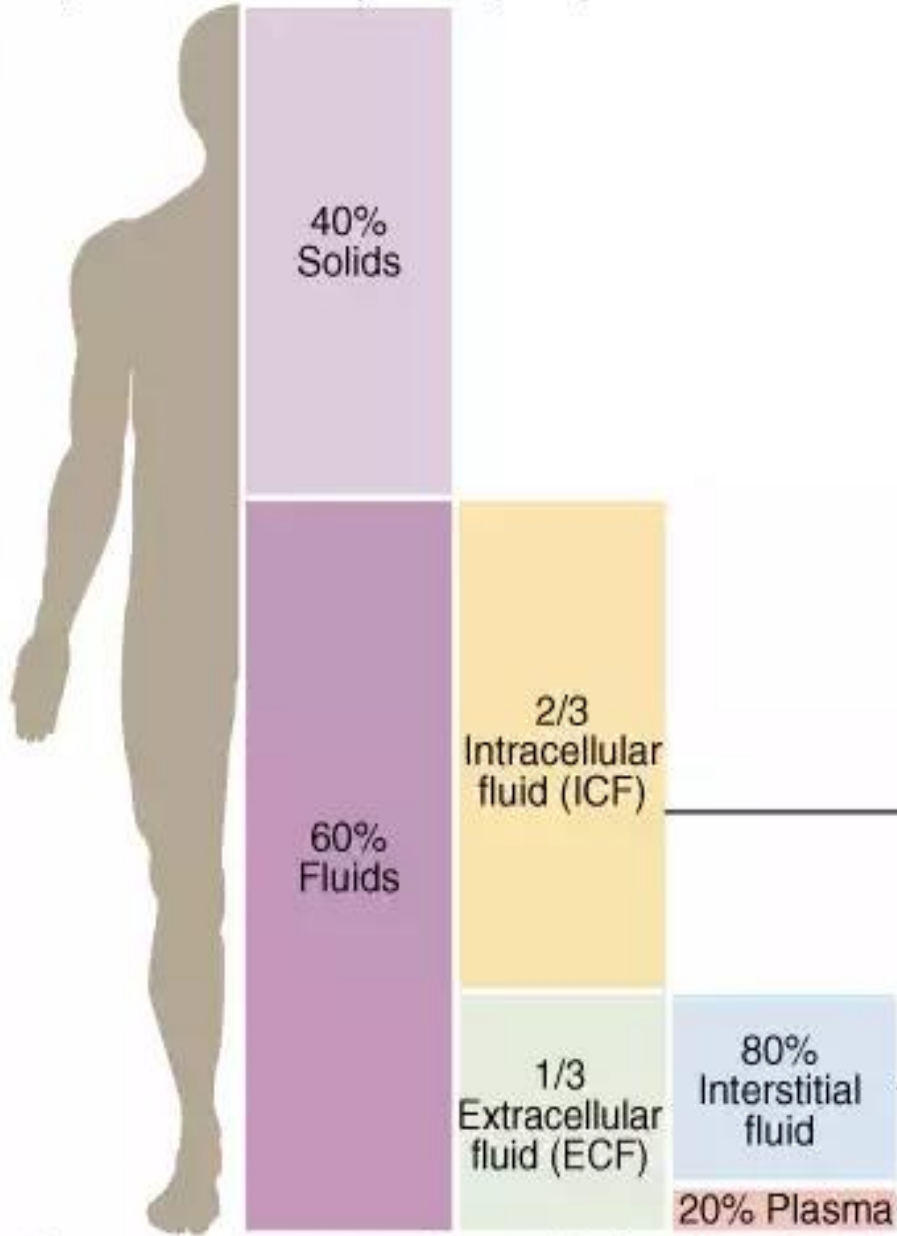


Water compartments of the human body

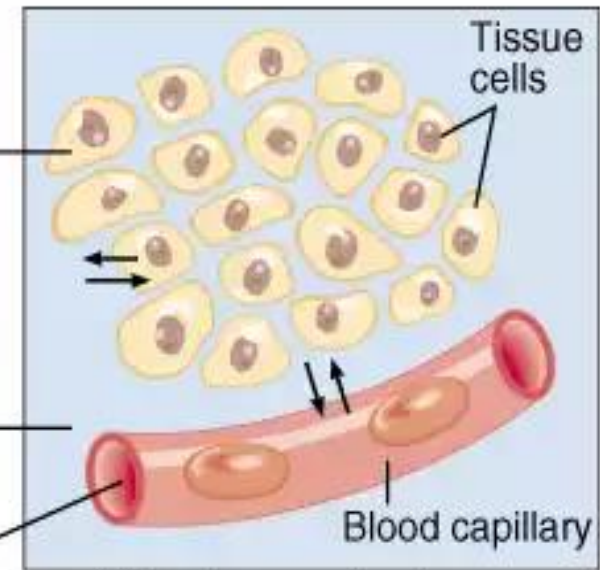
Total body mass (female)



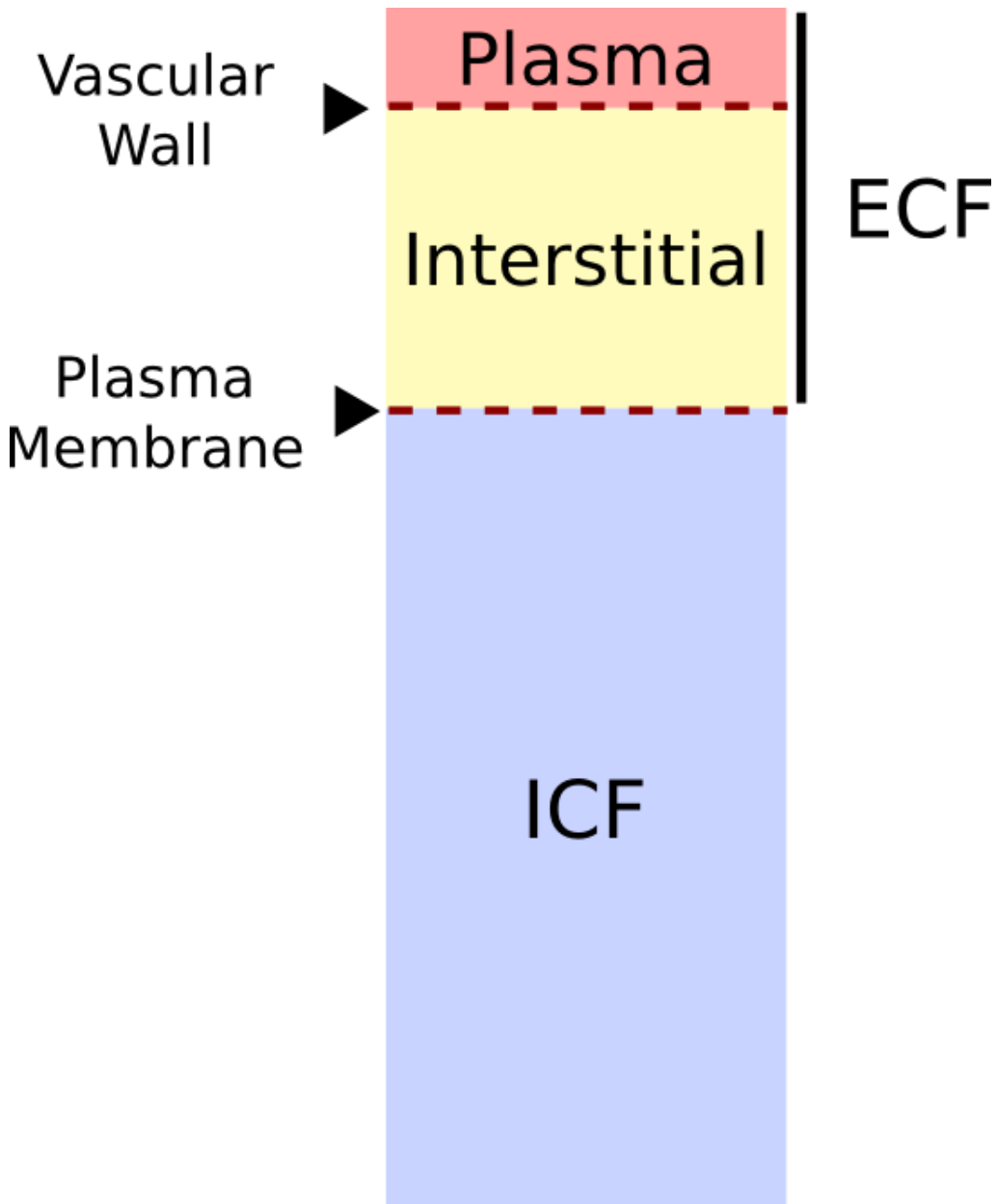
Total body mass (male)



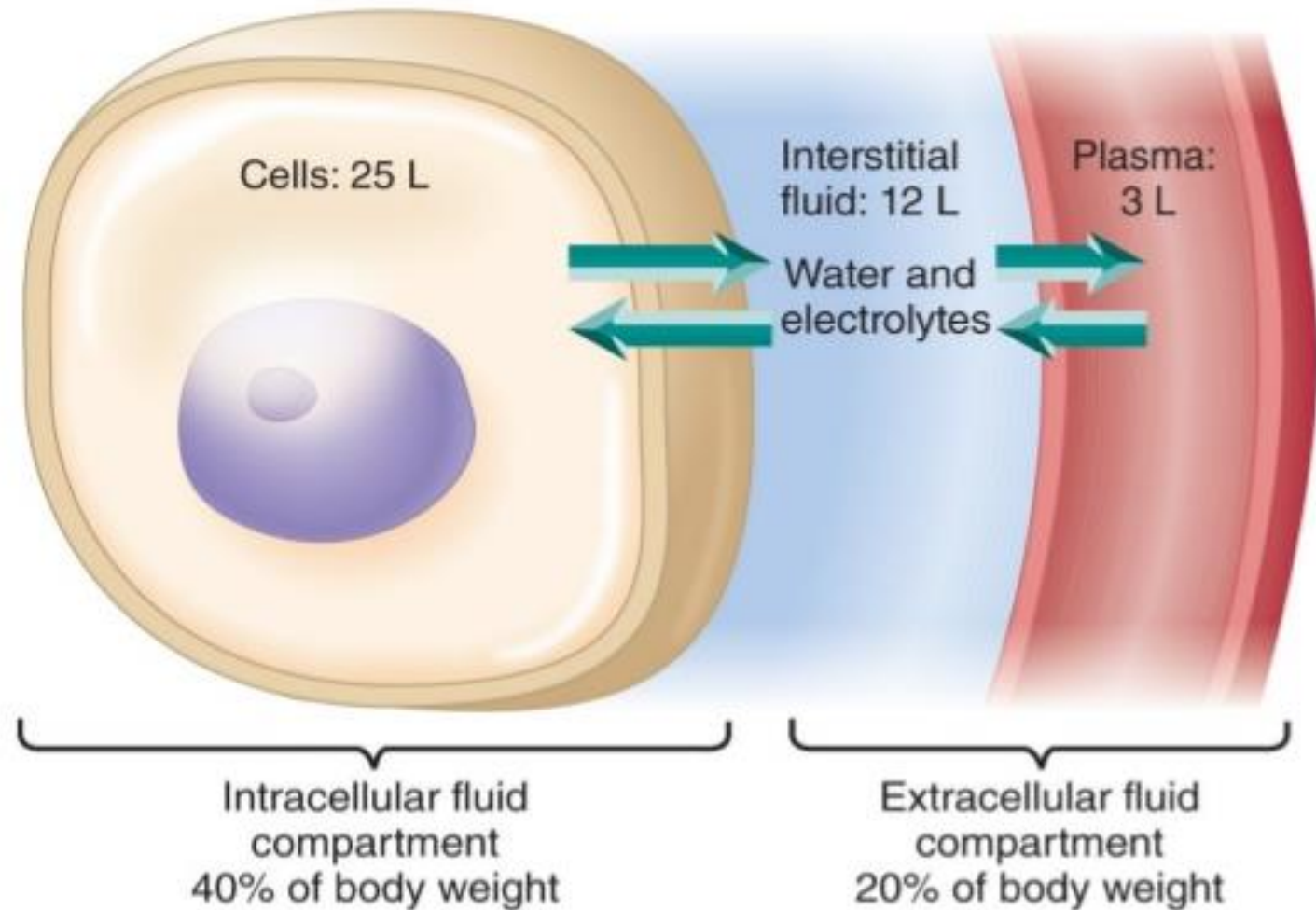
(a) Distribution of body water in an average lean, adult female and male



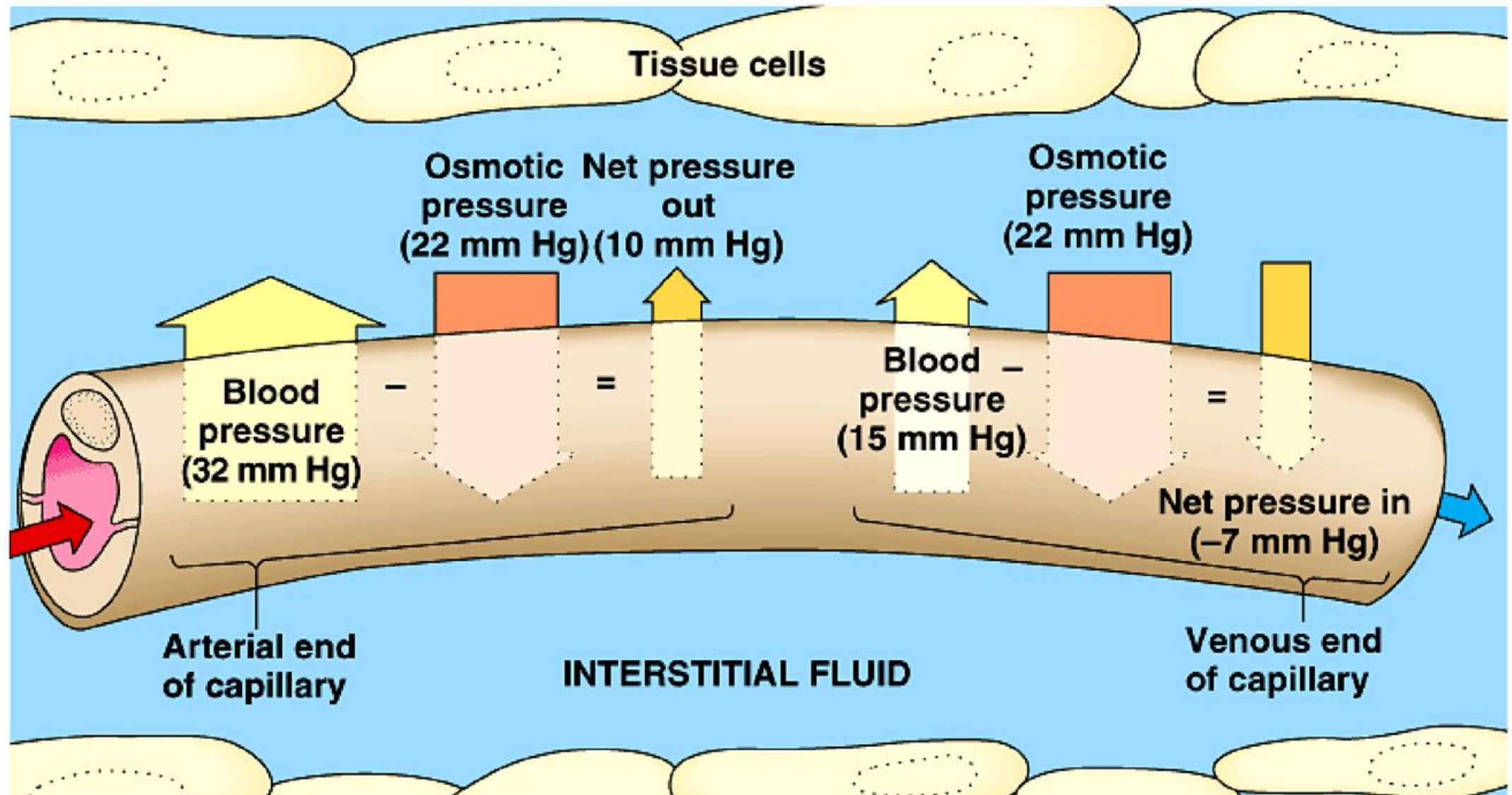
(b) Exchange of water among body fluid compartments



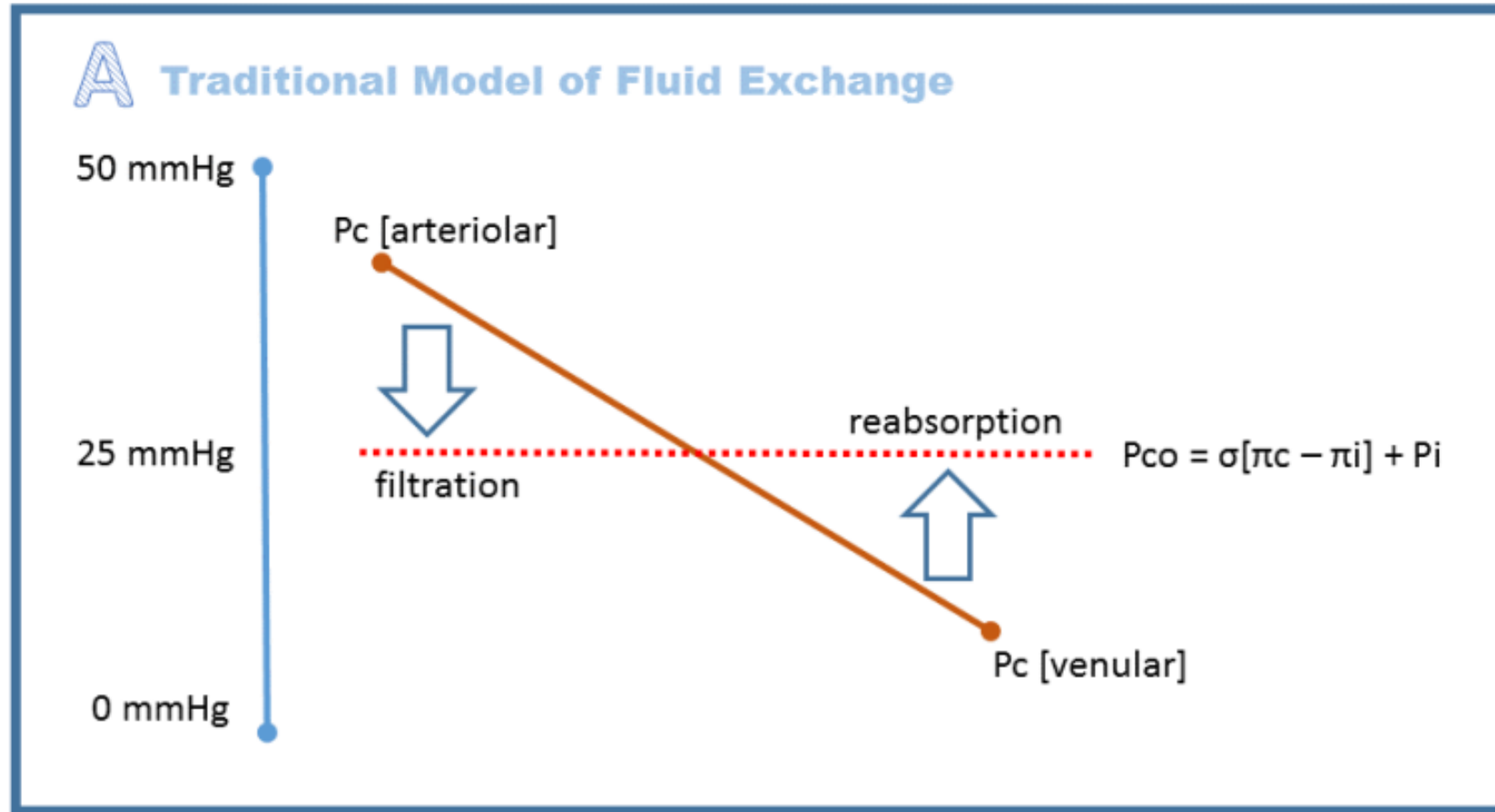
Major fluid compartments in the body



Starling's law of capillary filtration



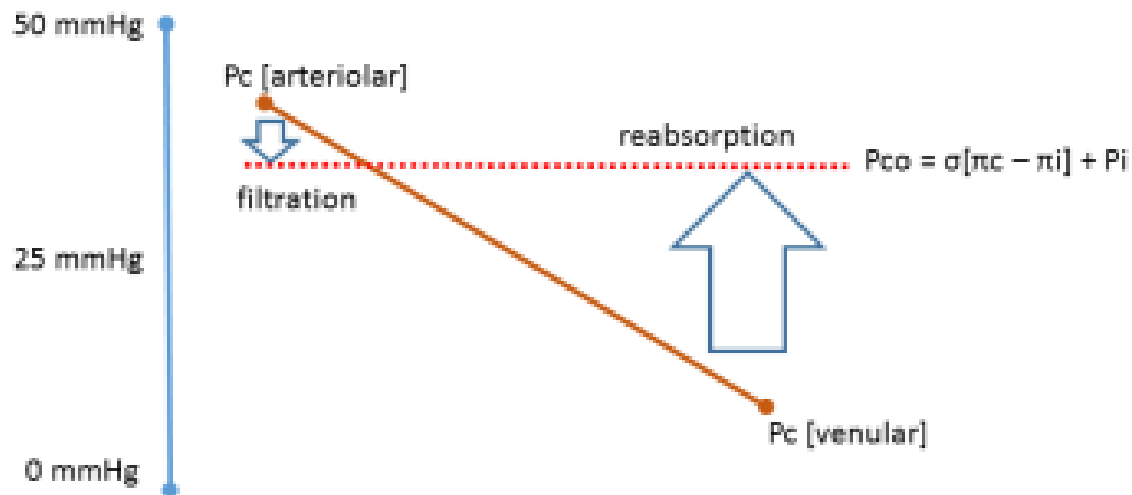
Revision of the Starling's law



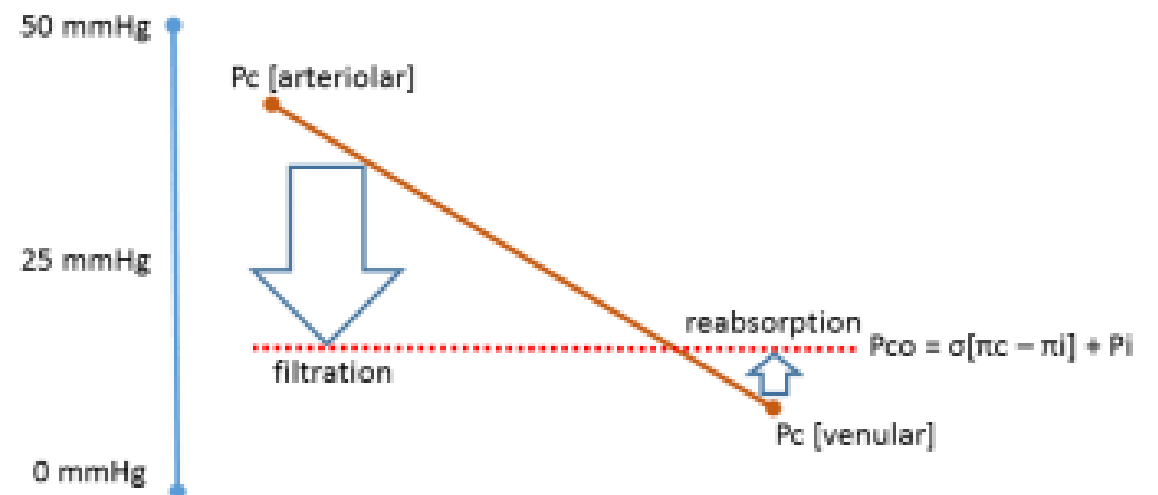
The hydrostatic pressure within the capillary [Pc] is represented by the sloped brown line. The sum-of-pressures opposing the Pc is the Pco, represented by the dotted red line in the middle. When the Pc is above the Pco, filtration occurs, when the Pc is below the Pco, absorption occurs. This is the traditional Starling Model.

Revision of the Starling's law

B Increased opposition pressure

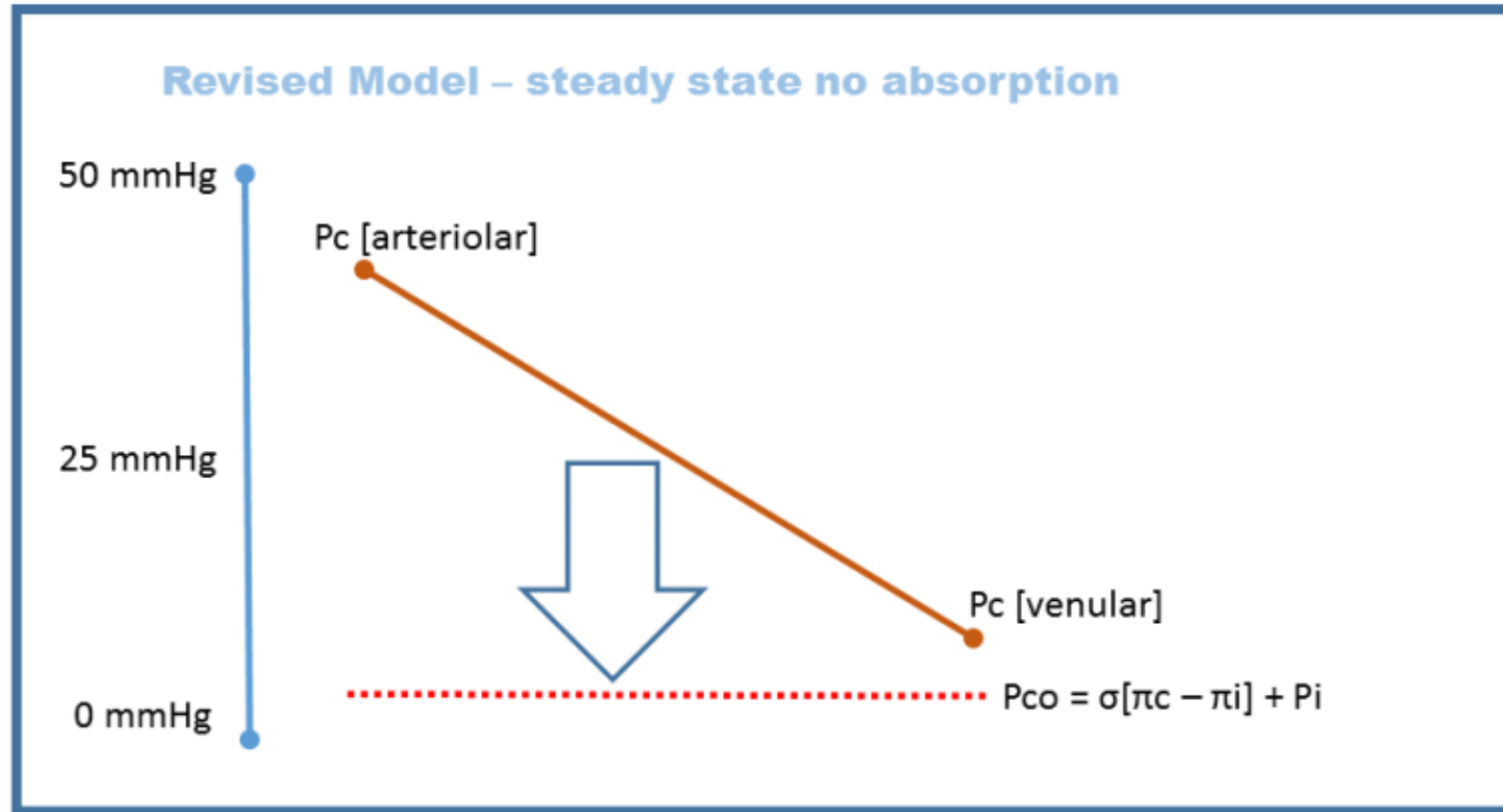


C Decreased opposition pressure



Hypothetical changes in the opposition pressure. Note that the P_{co} may rise [B] in response to an increase in π_c or P_i or a fall in π_i . This favours absorption. Conversely, P_{co} will fall [C] secondary to a fall in π_c or P_i , or a rise in π_i . This favours filtration

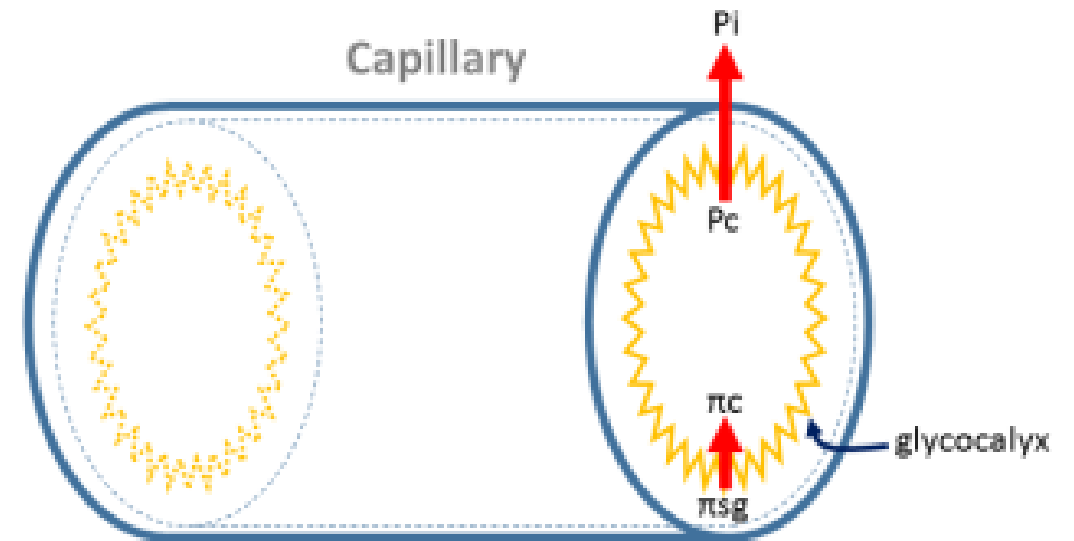
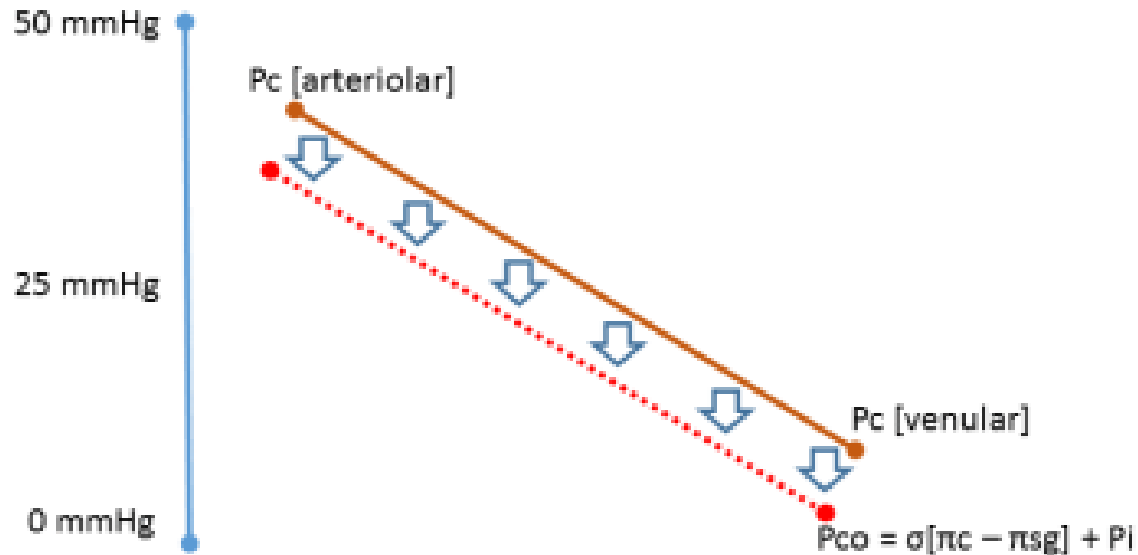
Revision of the Starling's law



The no-absorption rule [in the steady state]. Note that this occurs in the vast majority of capillaries. The high π_i and low P_i both diminish the P_{co} such that P_c is $> P_{co}$ throughout the capillary and filtration dominates [downward blue arrow].

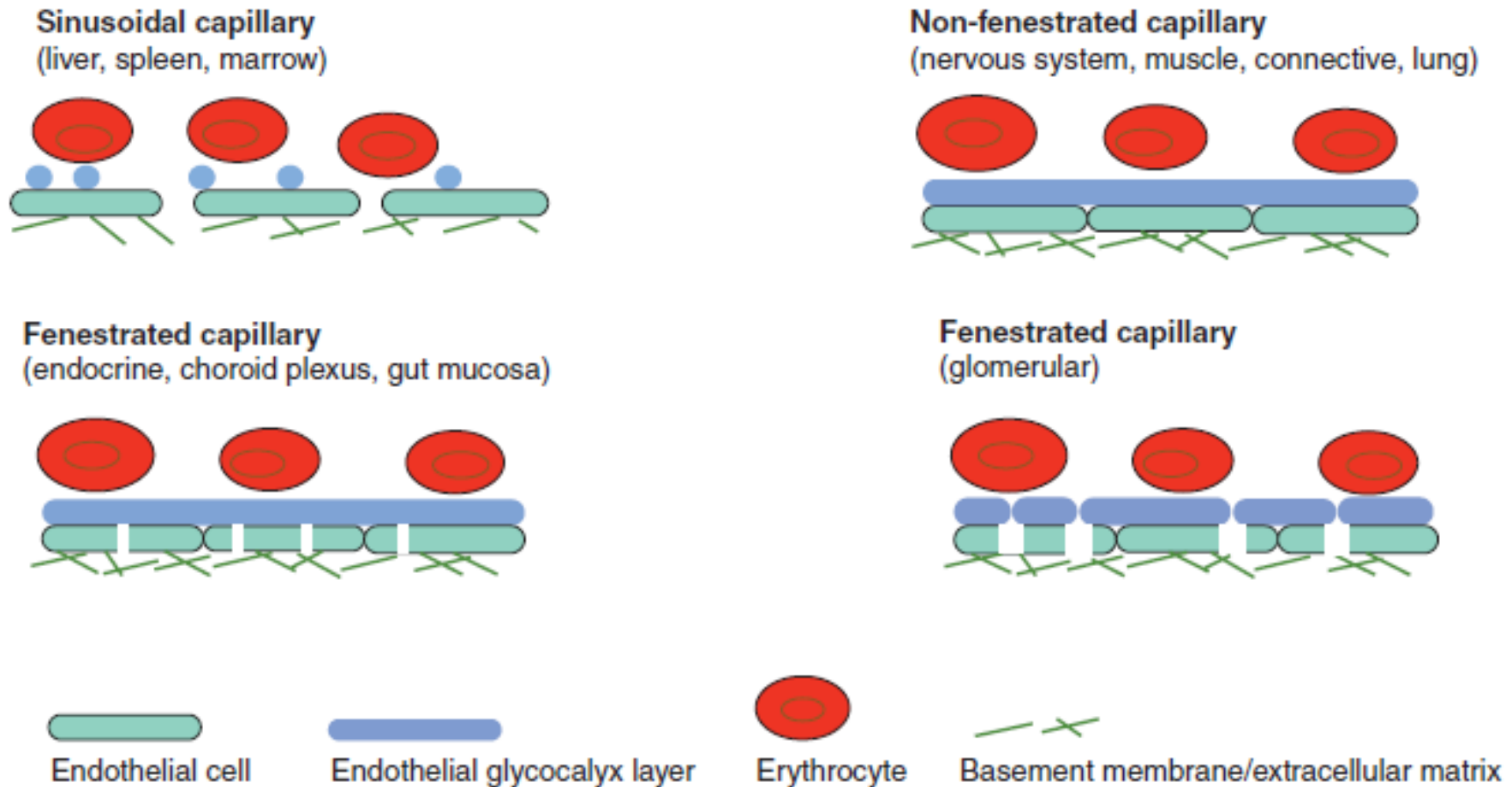
Revision of the Starling's law

Revised Model – the endothelial glycocalyx model



The glycocalyx model showing filtration throughout the capillary, but at a lower value due to the difference between the colloid osmotic pressure within the capillary [π_c], less the low colloid osmotic pressure in the sub-glycocalyx space [π_{sg}].

Revision of the Starling's law



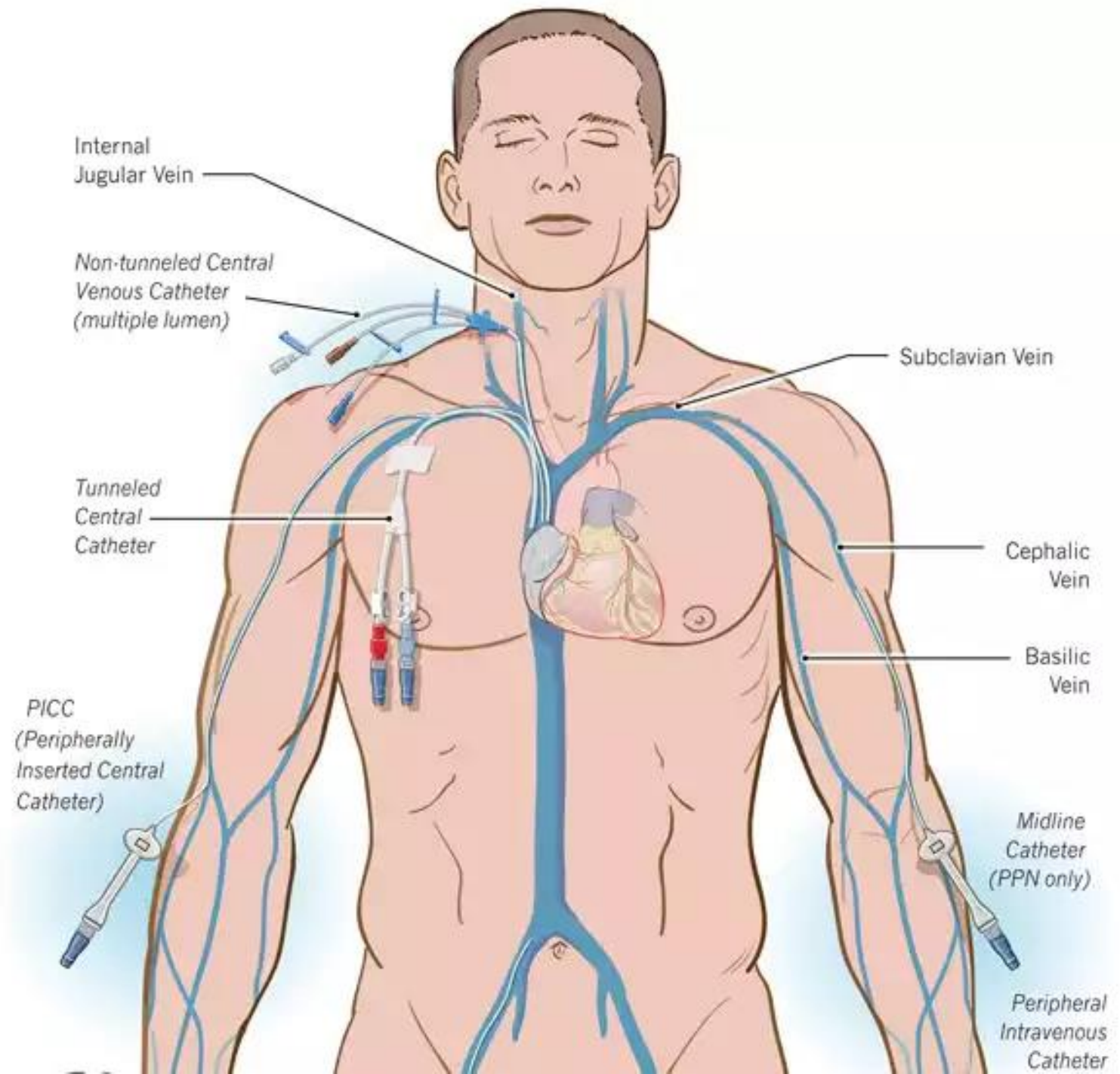
Infusion therapy

1. Administration of a *big amount of fluids* into the vessel to improve body functions.
2. The treatment of a patient with intravenously applied *infusion solutions* in order to enable a patient's recovery or improvement of his illness. Depending on the underlying illness, the solution contains an appropriate active pharmaceutical ingredient.
3. Intravascular administration of *any pharmacological active solution*.

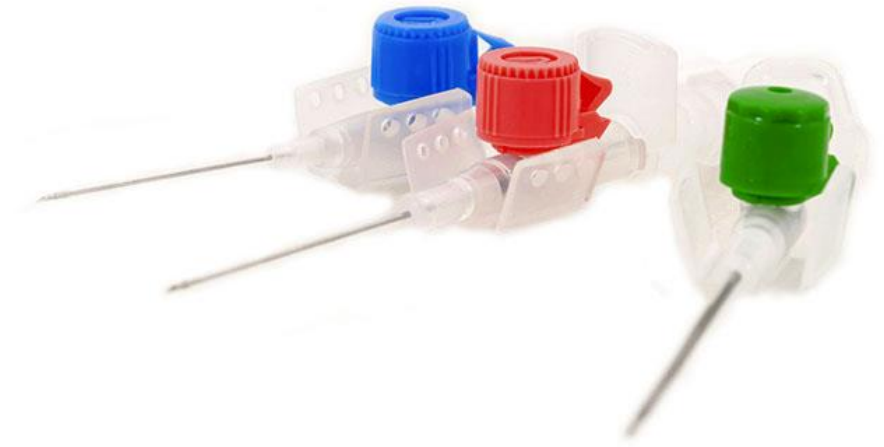


Ways of fluid administration

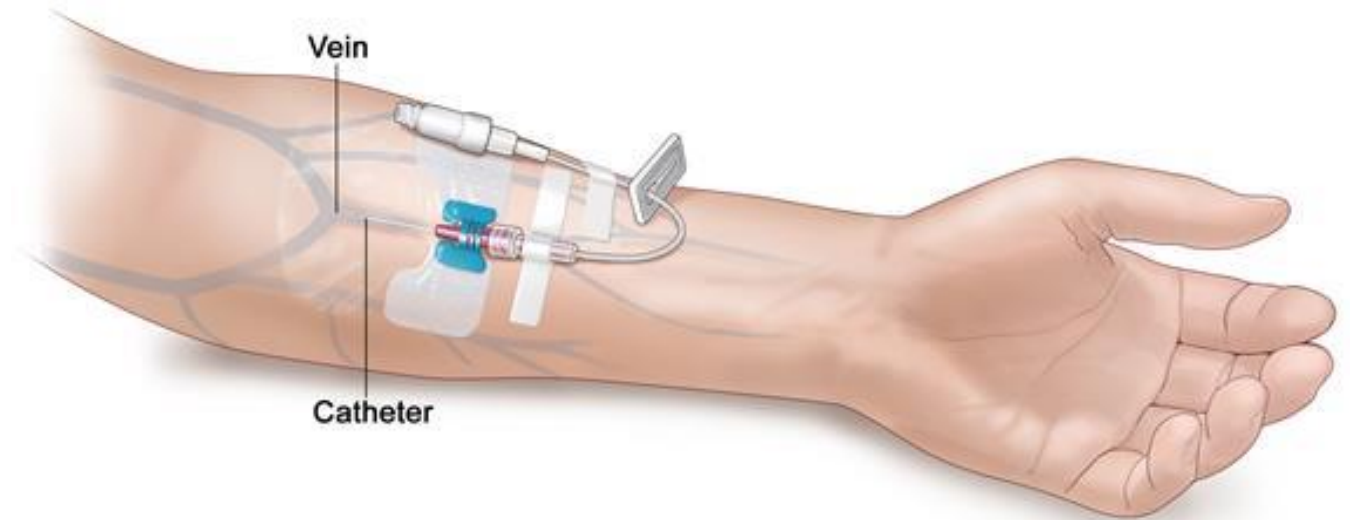
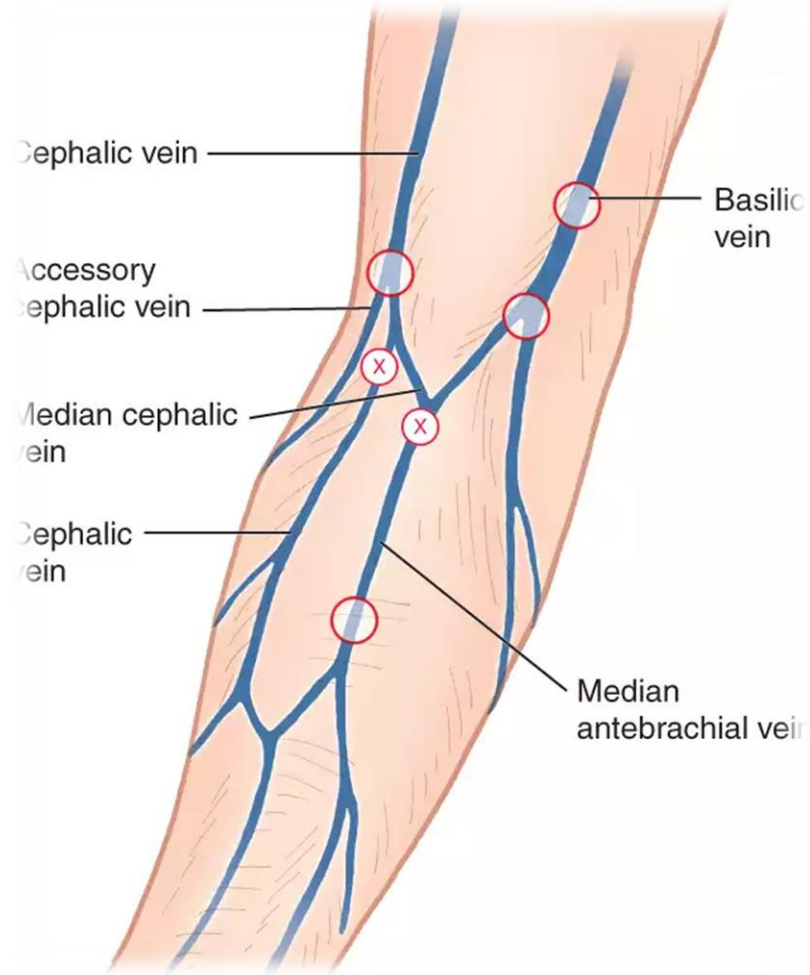
- Intravenous
 - Peripheral venous access
 - Puncture
 - Catheterization
 - Central venous access
 - Non-tunneled
 - Peripherally inserted central catheters
 - Tunneled
 - Subcutaneous port
- Intraarterial
- Intraosseous



Peripheral venous access

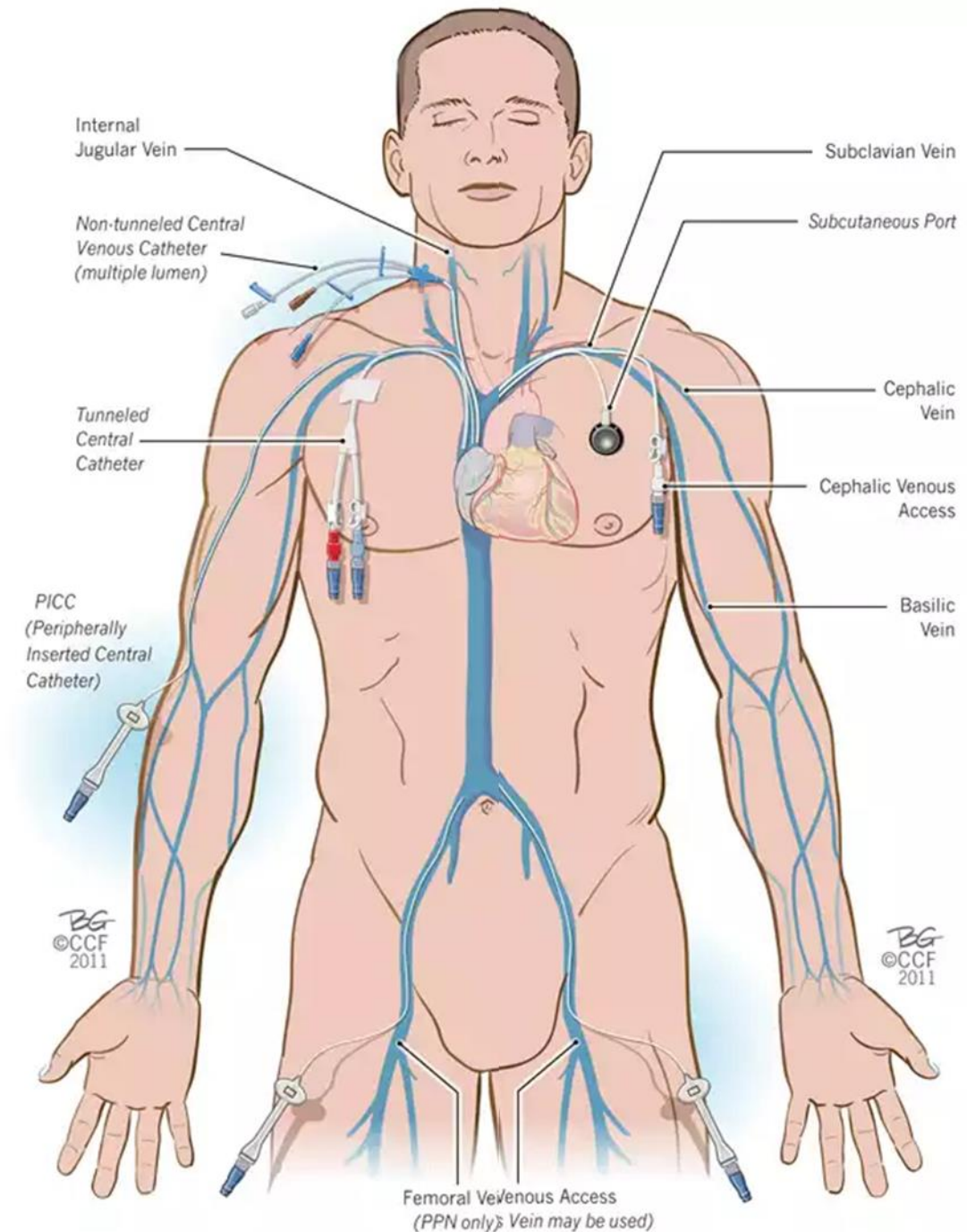


Peripheral Venous Catheter



Central venous access

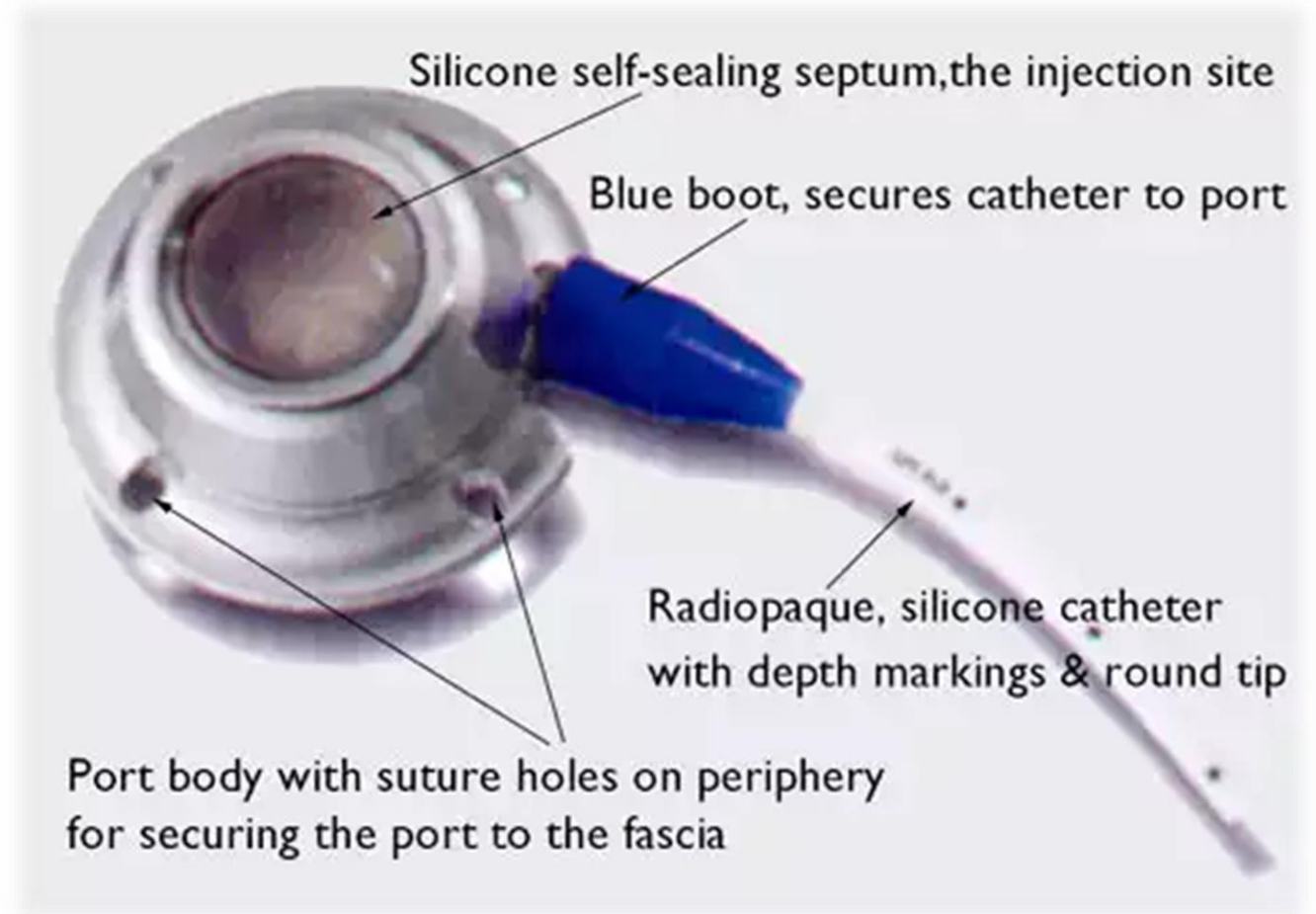
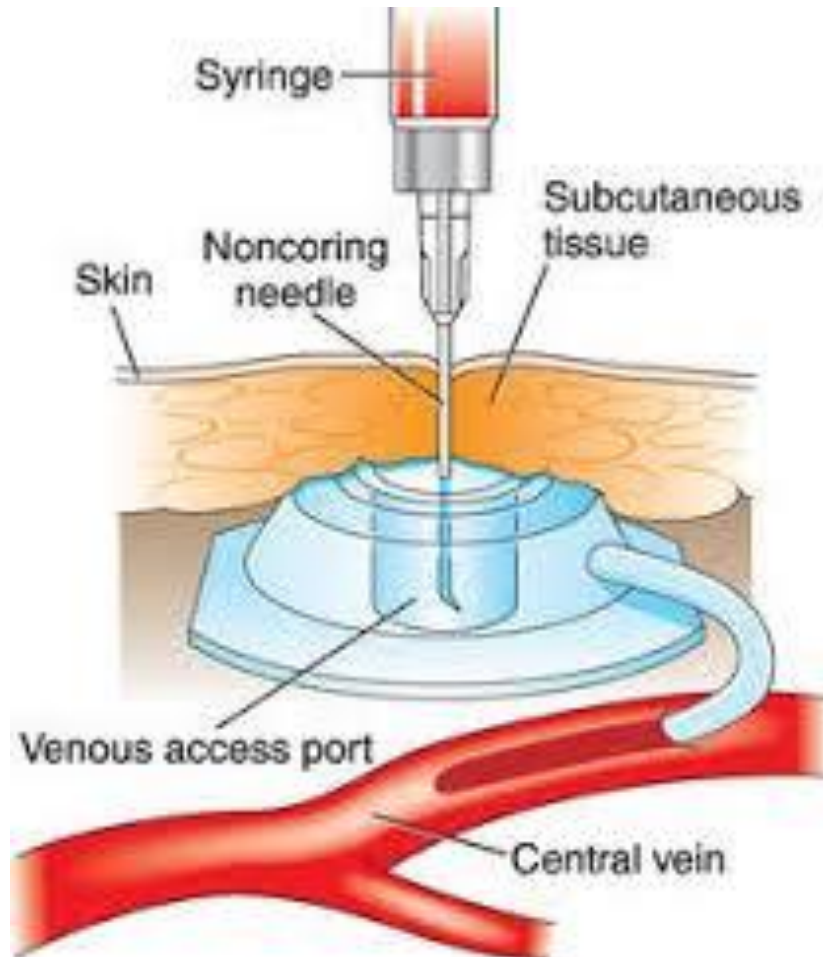
- Site:
 - External jugular vein
 - Internal jugular vein
 - Subclavian vein
 - Femoral vein
- Types:
 - Non-tunneled catheter
 - Tunneled catheter
 - Peripherally inserted central catheters
 - Subcutaneous port



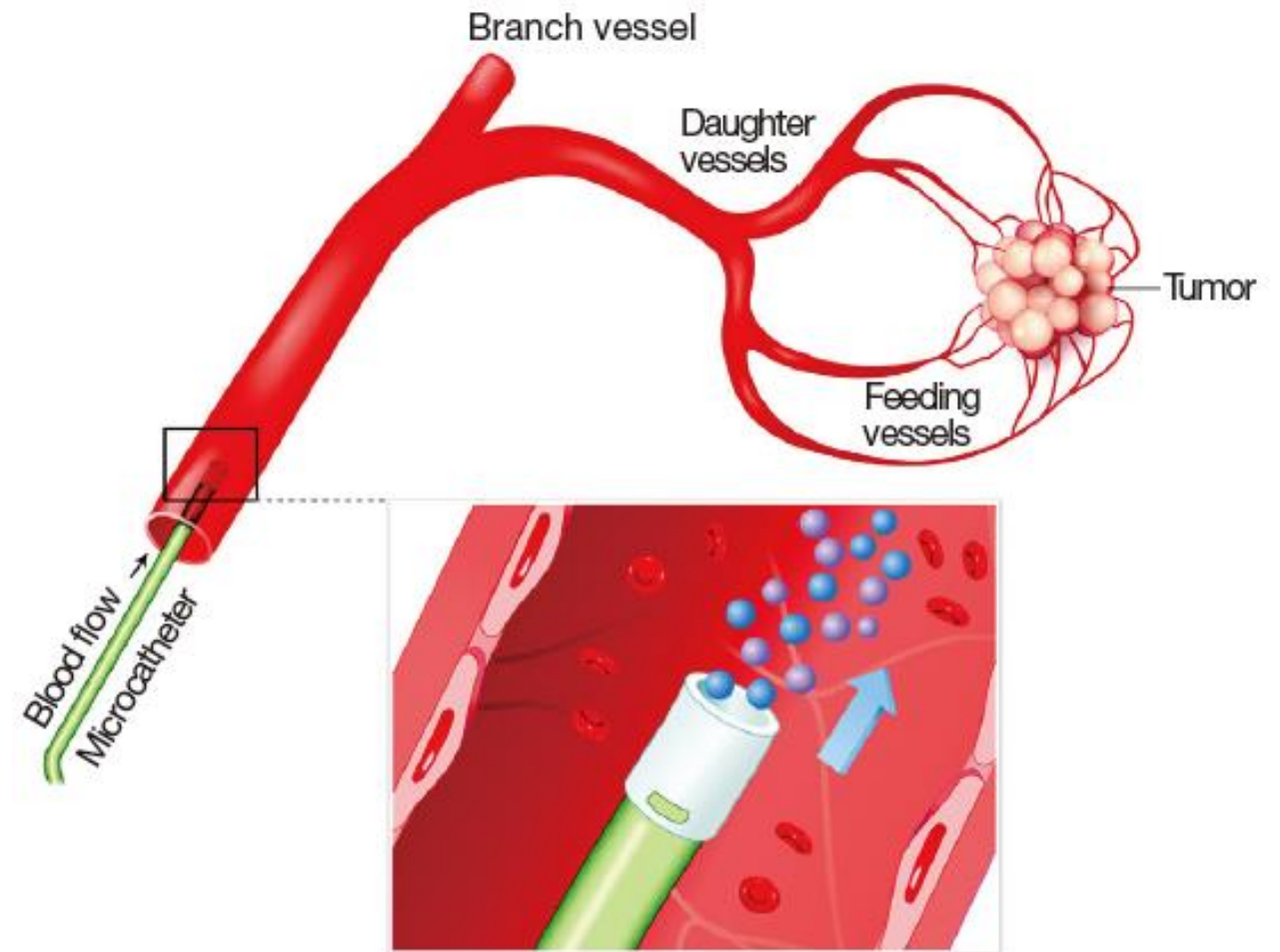
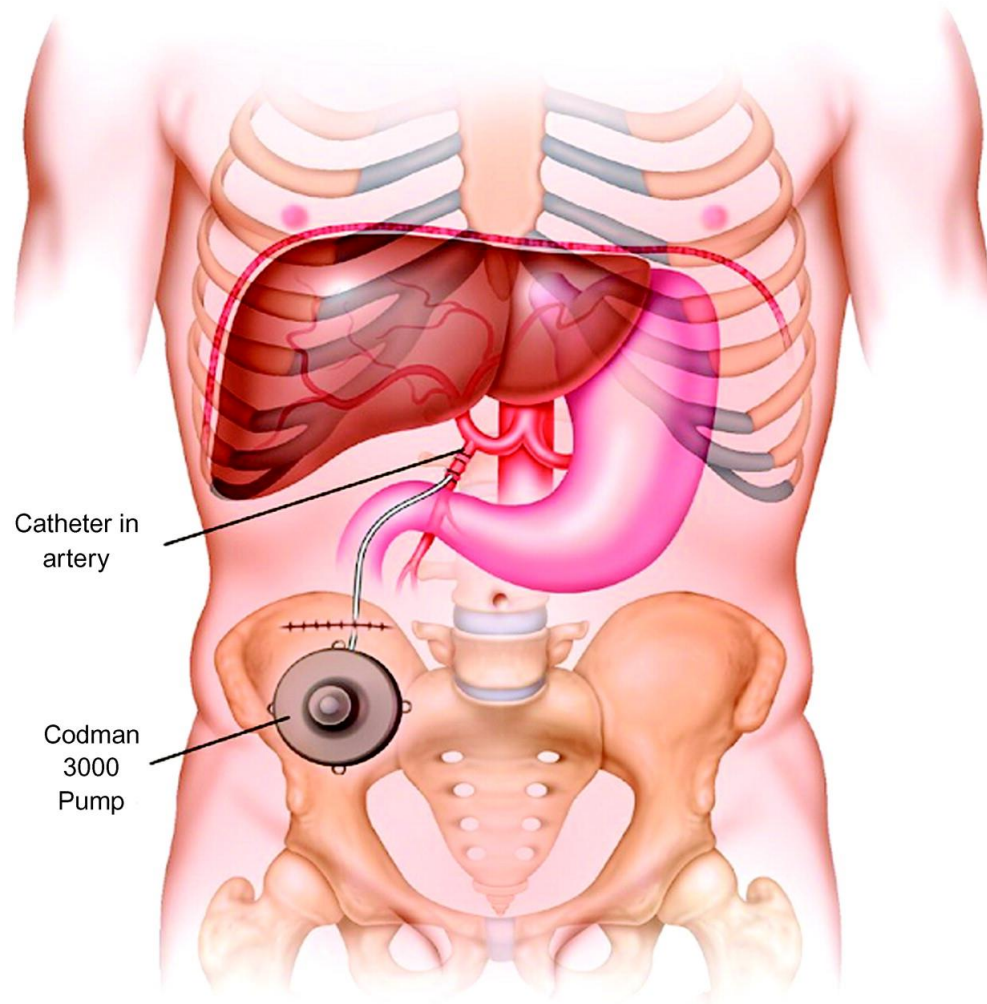
Indications for central venous access

- Inadequate peripheral venous access
 - Small collapsed veins
 - Hypotension
 - Big amount of infusions
- Administration of noxious medications such as vasopressors, chemotherapy, and parenteral nutrition are typically administered by central venous catheters because they can cause vein inflammation (phlebitis) when given through a peripheral intravenous catheter
- Hemodynamic monitoring: central venous access permits measurement of central venous pressure, venous oxyhemoglobin saturation (ScvO₂), and cardiac parameters (via pulmonary artery catheter)
- Extracorporeal therapies: large bore venous access is required to support high-volume flow required for many extracorporeal therapies, including hemodialysis, continuous renal replacement therapy, and plasmapheresis

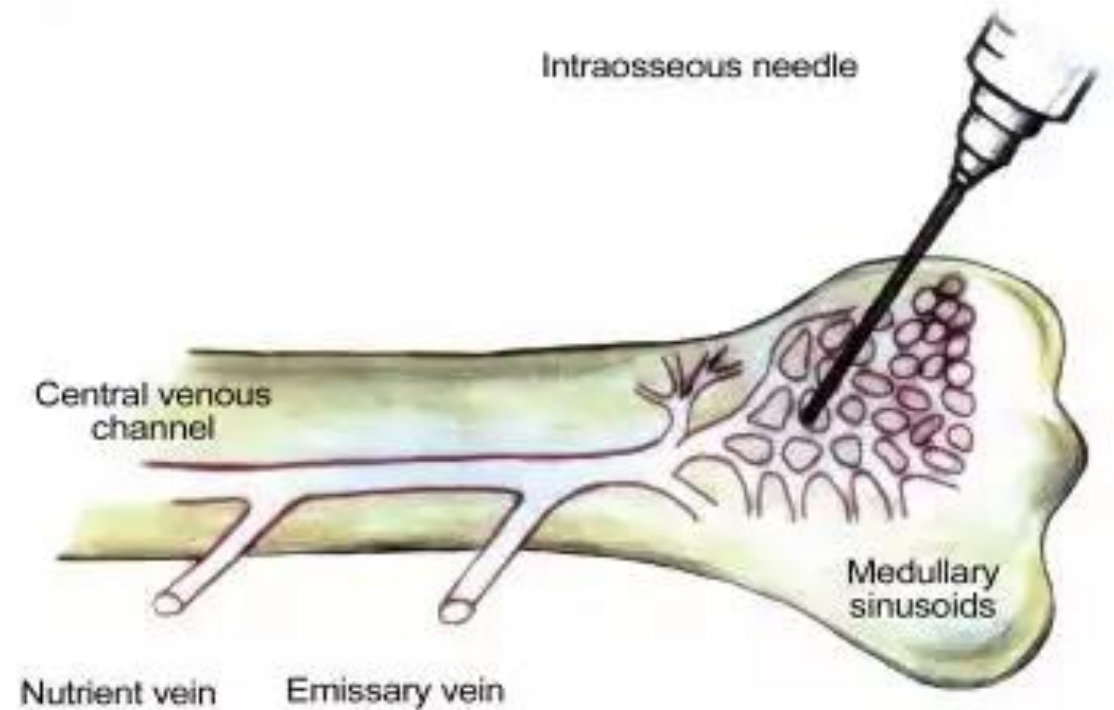
Subcutaneous port

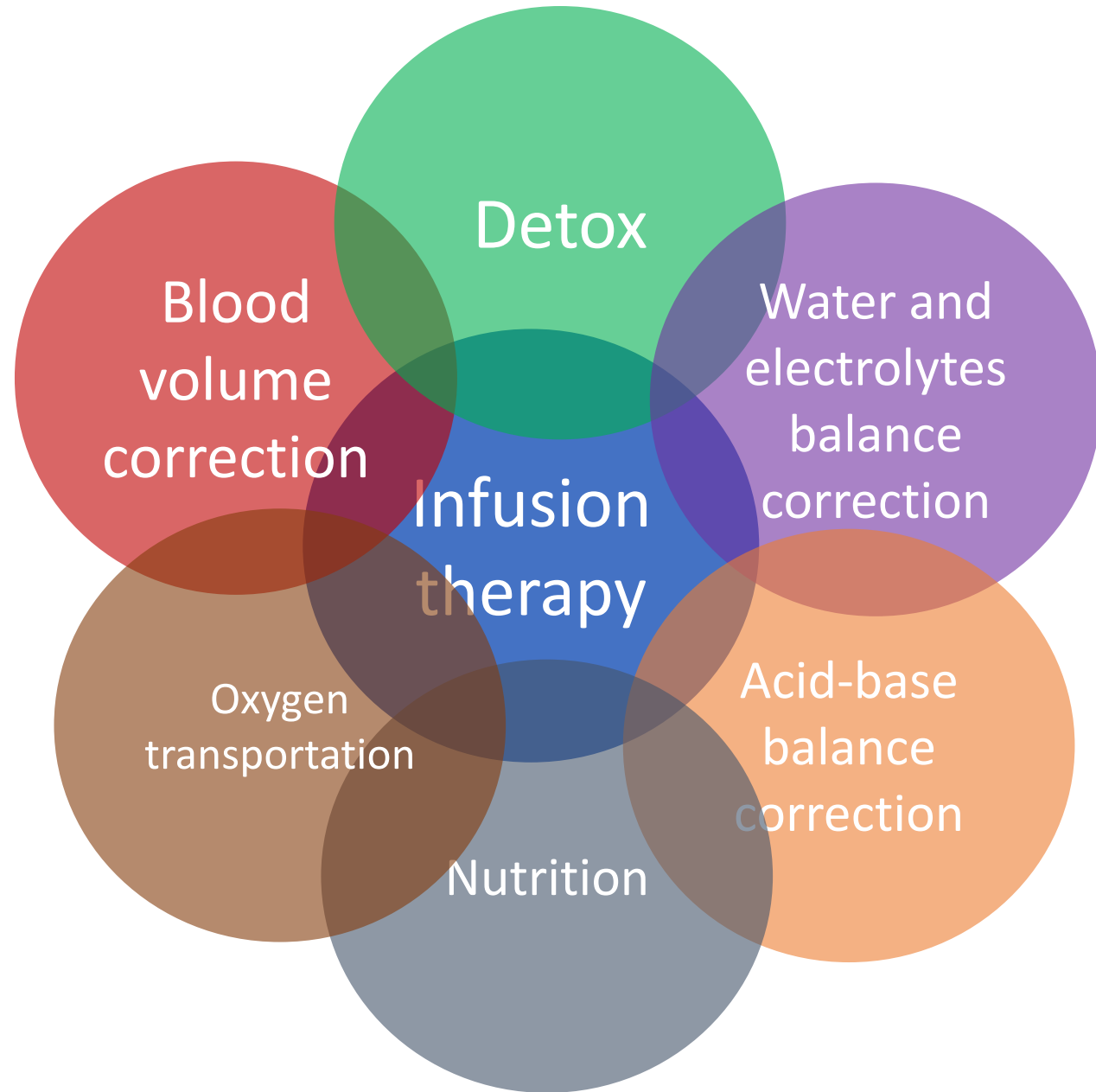


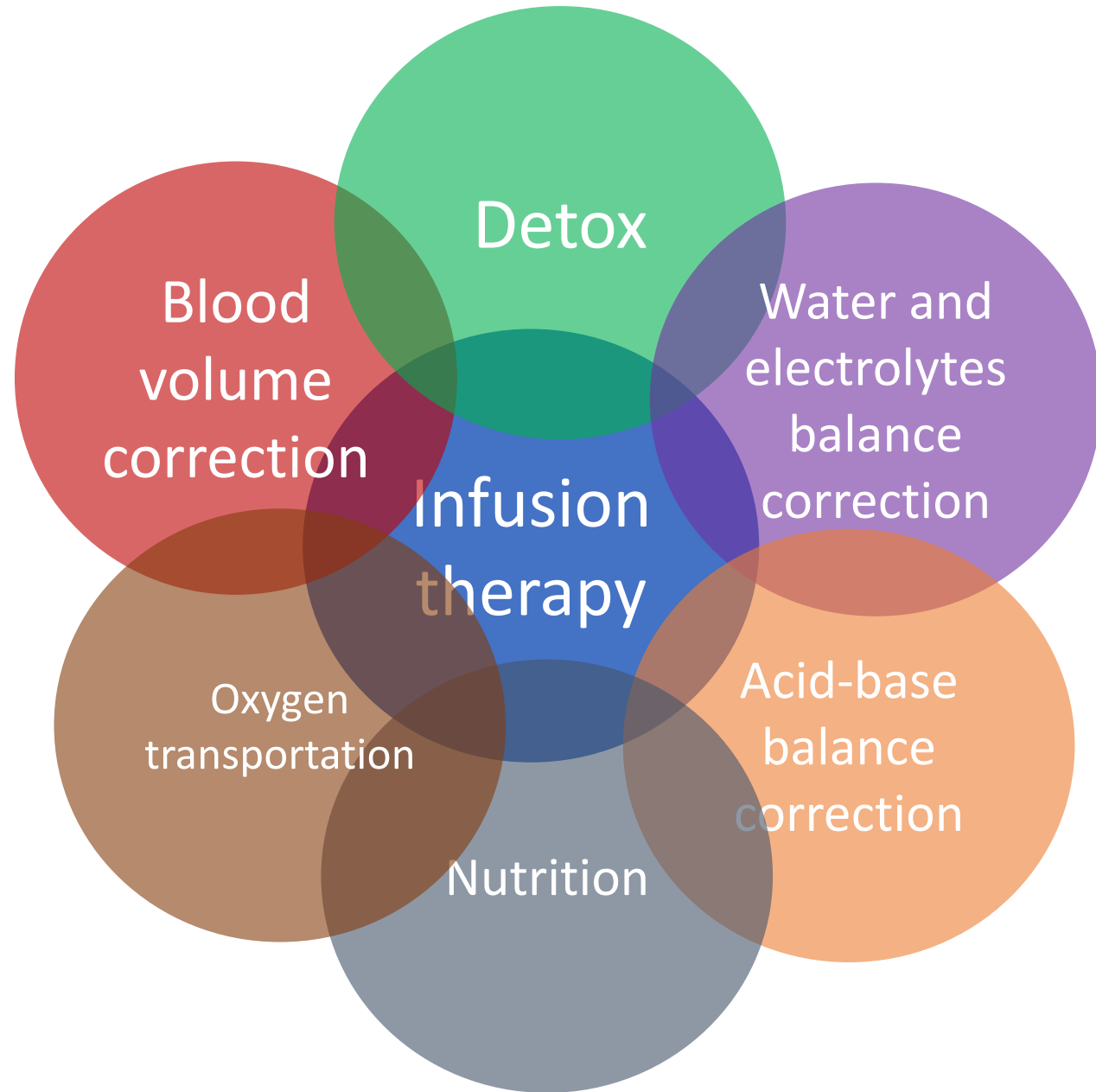
Intraarterial infusion



Intraosseous Infusion

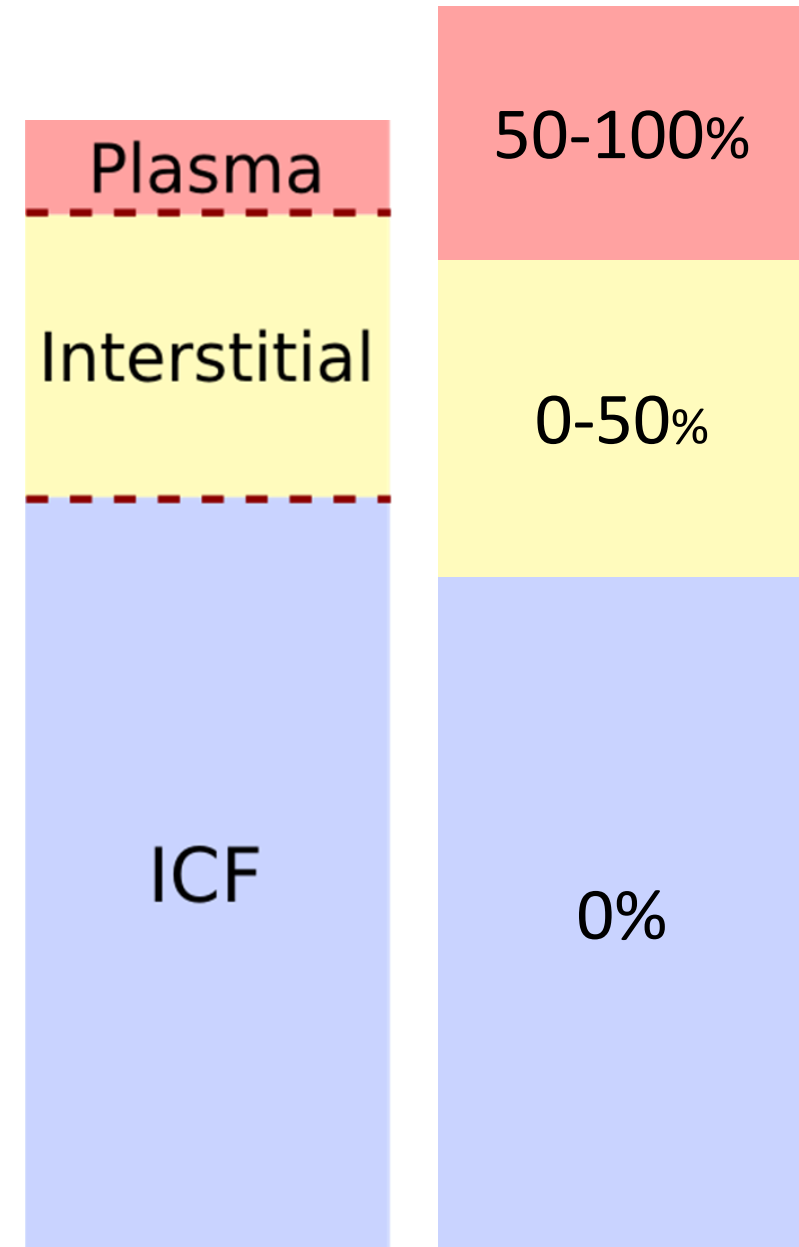






Volume expanders

- Colloid solutions
- High osmotic pressure
- Can move the fluid from interstitium (?)
- Can save the fluid into the vessels
- Long time of circulation
- Increase cardiac output
- Increase microcirculation and oxygen delivery
- Affect hemostasis
- Decrease capillary permeability



Volume expanders (colloids)

- Activity depends on the osmotic pressure
- Time of action depends on
 - Moving to the interstitium
 - Size of the molecule
 - Way of elimination
 - Glomerular filtration
 - Intestinal filtration
 - Enzymatic hydrolysis

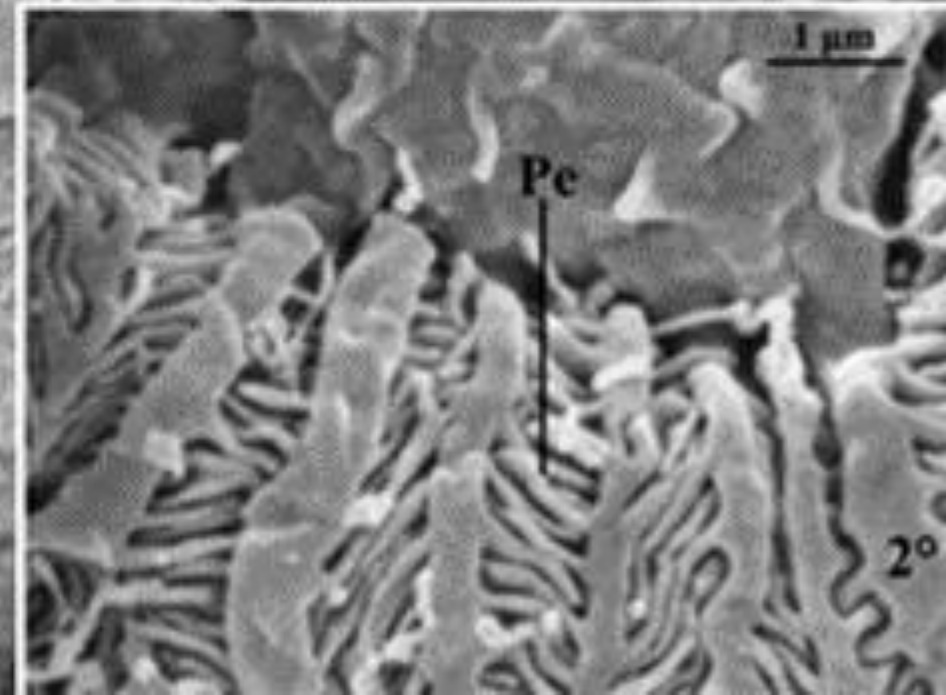
Indicator of activity – volume coefficient (V_c)

$$V_c = V_{\text{increase}} / V_{\text{ifused}}$$

- $V_c = 1,0$: blood volume increased for 1000 ml after infusion of 1000 ml
- $V_c = 1,5$: blood volume increased for 1500 ml after infusion of 1000 ml
- $V_c = 0,2$: blood volume increased for 200 ml after infusion of 1000 ml

Glomerular filtration

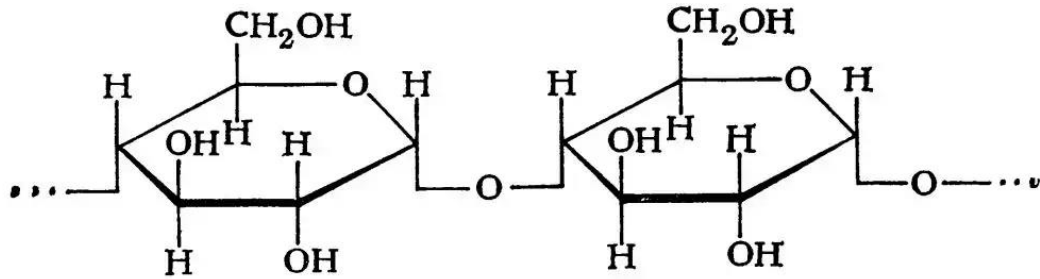
- Molecular weight
- Molecular size
 - Different molecules can have the same weight but different sizes
- Good filtration (<60 kDa)
 - β_2 -microglobuline (10-25 kDa)
 - α_1 -microglobuline (25-30 kDa)
 - Prealbumin, albumin, postalbumine (60-70 kDa)
- Molecular charge
 - Negative charge of endothelial glycocalyx



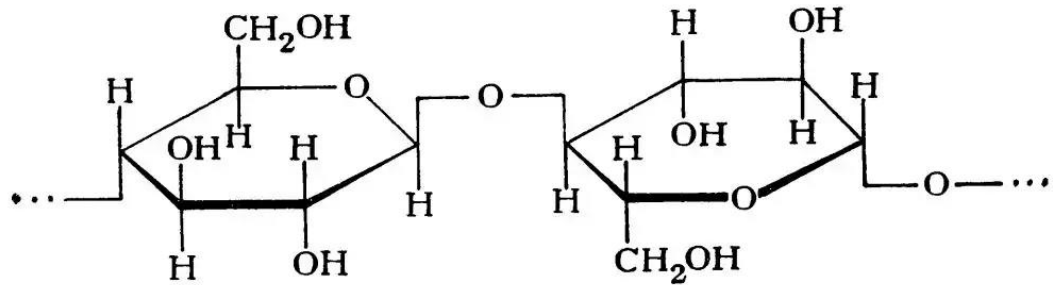
Colloids

- Homogeneous non-crystalline substance consisting of large molecules or ultramicroscopic particles of one substance dispersed through a second substance - the particles do not settle and cannot be separated out by ordinary filtering or centrifuging like those of a suspension such as blood.
- Colloid solutions used in clinical practice for fluid therapy are divided into the semisynthetic colloids (**gelatins, dextrans and hydroxyethyl starches**) and the naturally occurring human plasma derivatives (**human albumin solutions, plasma protein** fraction, fresh frozen plasma, and immunoglobulin solution).
- Most colloid solutions are presented with the colloid molecules dissolved in isotonic saline but isotonic glucose, hypertonic saline and isotonic balanced or “physiological” electrolyte solutions are also used

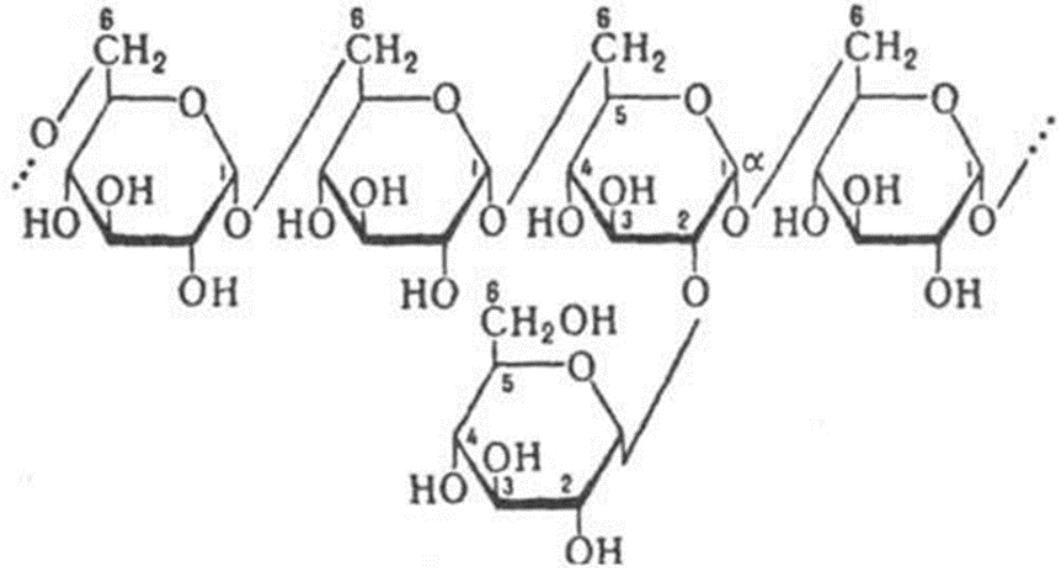
Dextrans



Starch (alpha-glucose polymer with 1-4 bonds)



Cellulose (beta-glucose polymer with 1-4 bonds)



Dextran (alpha-glucose polymer with 1-6 bonds)

Dextrans are biosynthesized commercially from sucrose by *Leuconostoc* bacteria using the enzyme dextran sucrose. The high molecular weight dextrans produced are then cleaved by acid hydrolysis and separated by repeated ethanol fractionation into a final product with a restricted molecular weight range. The products of this process are D-glucose polymers joined largely by alpha 1,6 bonds into predominantly linear macromolecules.

Dextrans

- Dextran 70

- MW of 70 kDa
- $V_c = 1,4$
- Time of circulation – 3-7 days
- Excreted through the gut or metabolized by endogenous dextranases in reticuloendothelial cells

- Dextran 40

- MW of 40 kDa
- $V_c = 1,7$
- Time of circulation – 2-24 hours
- Elimination by renal filtration
- Reduce cell aggregation and plasma viscosity
- Antithrombotic effect
- Increase microcirculation

Dextrans

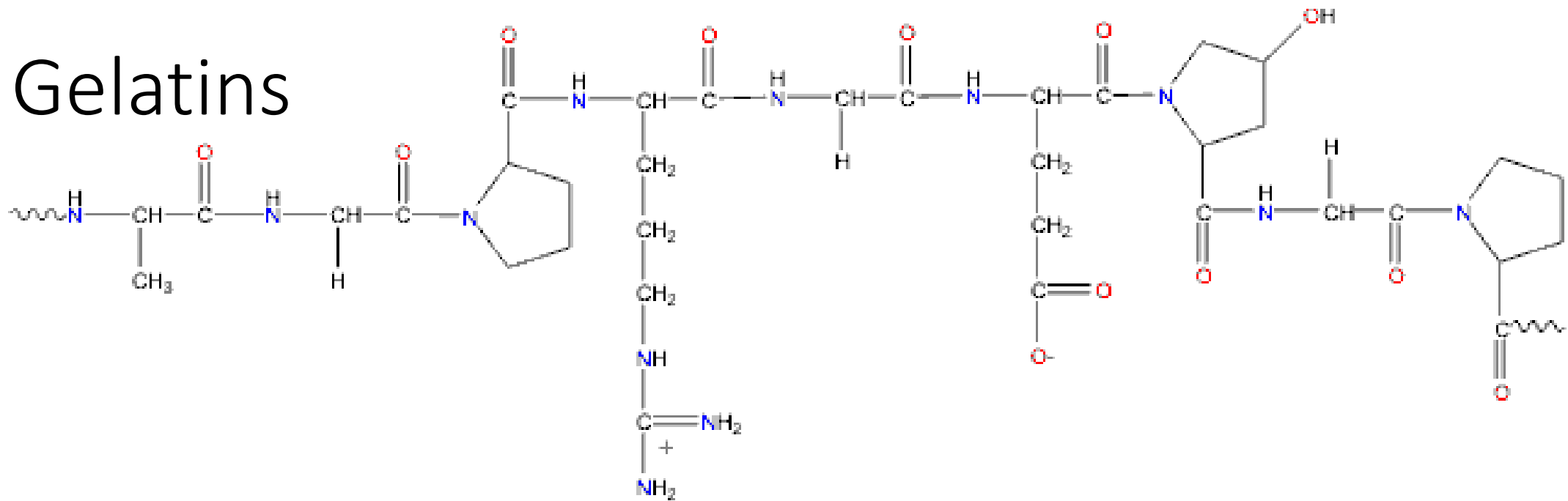
Pro

- Effectively increase blood volume
- High volume coefficient
- Increase microcirculation and rheology
- Long volume expand effect
- Low cost

Contra

- Dose-dependent decrease of coagulation
- Increase parenchymatous bleeding
- Activate fibrinolysis
- Decrease vWF and FVIII activity
- Decrease fibrinogen activity
- Decrease platelets aggregation
- Decrease count of platelets
- Inability to test blood group
- Acute renal failure
- Lack of metabolizing
- Long circulation
- Restricted dose

Gelatins



Gelatins are prepared by hydrolysis of bovine collagen. Succinylated gelatin (Gelofusin™) is produced by enzymatic alteration of the basic gelatin peptide and is presented in isotonic saline. Succinylation causes a conformational change that increases molecular size without significantly increasing molecular weight. Urea linked gelatin (polygeline, Haemaccel™) is produced by thermal degradation of the raw material to small peptides (12000 to 15000 Dalton) followed by urea cross-linking to produce polymers of around 35000 Daltons

Gelatins

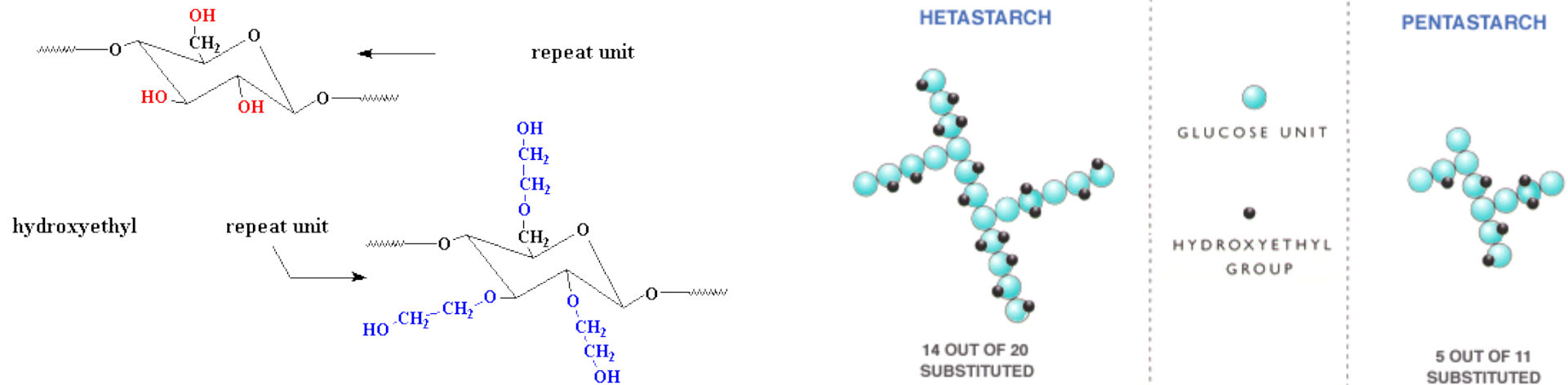
Pro

- Affect hemostasis (decrease of vWF and VIII) but do not increase bleeding
- High Vc
- No infection risks
- Low risk of allergy
- Big doses available
- Low cost
- Increase glomerular filtration

Contra

- Increase inflammation response
- Increase endothelial permeability
- Highest incidence of life-threatening reactions

Hydroxyethyl starches (HES)



Hydroxyethyl starches are synthesized from amylopectin, a branching D-glucose polymer derived from maize or sorghum. Hydroxyethyl substitution by ethylene oxide occurs in the presence of an alkaline catalyst. The majority of substitutions occur at carbon 2 in the glucose ring, with a minority occurring at carbon 3 and 6, and a higher C2/C6 substitution ratio results in slower enzymatic degradation.

Hydroxyethylation slows hydrolysis by non-specific amylases in the blood; unsubstituted starch molecules are rapidly metabolized. The degree of substitution (DS), expressed as a number between 0 and 1, describes the proportion of substituted to non-substituted glucose moieties and an increased DS confers greater resistant to hydrolysis.

HES

Pro

- High and predictable Vc;
- Protect capillaries;
- Reduce the severity of the systemic inflammatory response;
- Prevent the development of the capillary leakage syndrome;
- Do not cause additional activation of the complement system;
- Do not affect the expression of surface antigens of immunocompetent cells.
- Promote a higher growth of cardiac index, DO₂, better oxygen balance;
- Improve rheological properties of the blood by decreasing the adhesion and aggregation of platelets,
- Do not transmit infections,
- Have low risk for allergy;
- Stimulate glomerular filtration.

Contra

- Increase bleeding risk
- Acute renal failure
- Increase mortality in septic shock, burn disease, critically ill patients

Albumin

Pro

- Natural plasma protein
- High osmotic pressure
- Effect of general stimulation

Contra

- High risk for allergy
- Increase capillary leakage
- Increase interstitial edema

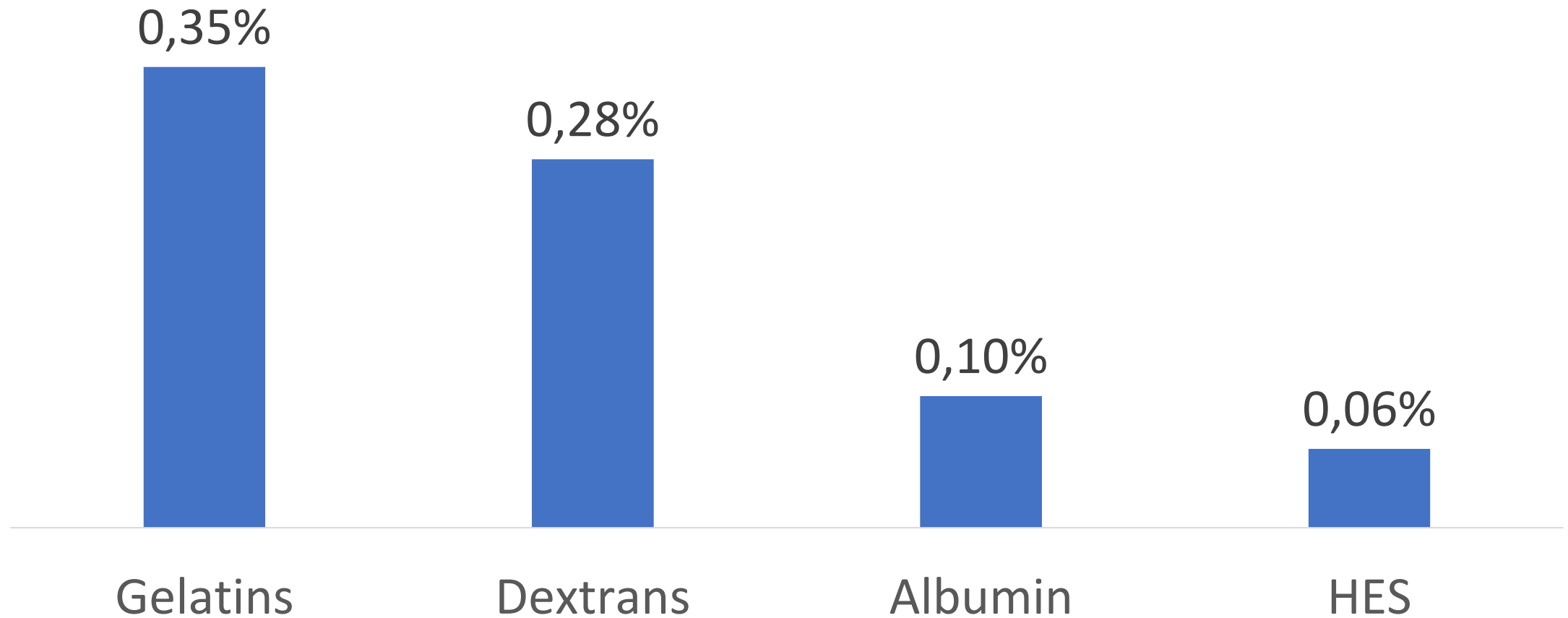
Solution	Colloid Type	MW _n /MW _w KDaltons	DS	Na ⁺ mmol/L	Cl ⁻ mmol/L	K ⁺ mmol/L	Ca ²⁺ mmol/L	Glucose mg/L
Hespan 6%	Hetastarch	70/450	0.7	150	150	-	-	-
Hextend	Hetastarch	70/450	0.7	143	124	3	5	90
EloHaes 6%	Pentastarch	60/250	0.5	154	154	-	-	-
HAES-steril 6% or 10%	Pentastarch	70/250	0.5	154	154	-	-	-
Pentaspan 10%	Pentastarch	70/250	0.45	154	154			
Voluven	Tetrastarch	60/130	0.4	154	154			
Volulyte	Tetrastarch	60/130	0.4	137	110	4		
Gelofusine (4%)	Succinylated Gelatin	30	-	154	154	-	-	-
Haemaccel (3.5%)	Polygeline	30	-	145	145	5.1	6.25	-
Gentran 40	Dextran 40	40	-	154	154	-	-	-50
Gentran 70	Dextran 70	70	-	154	154	-	-	50
Rheomacrodex	Dextran 40	40	-	154	154	-	-	50
Macrodex	Dextran 70	70	-	154	154	-	-	50

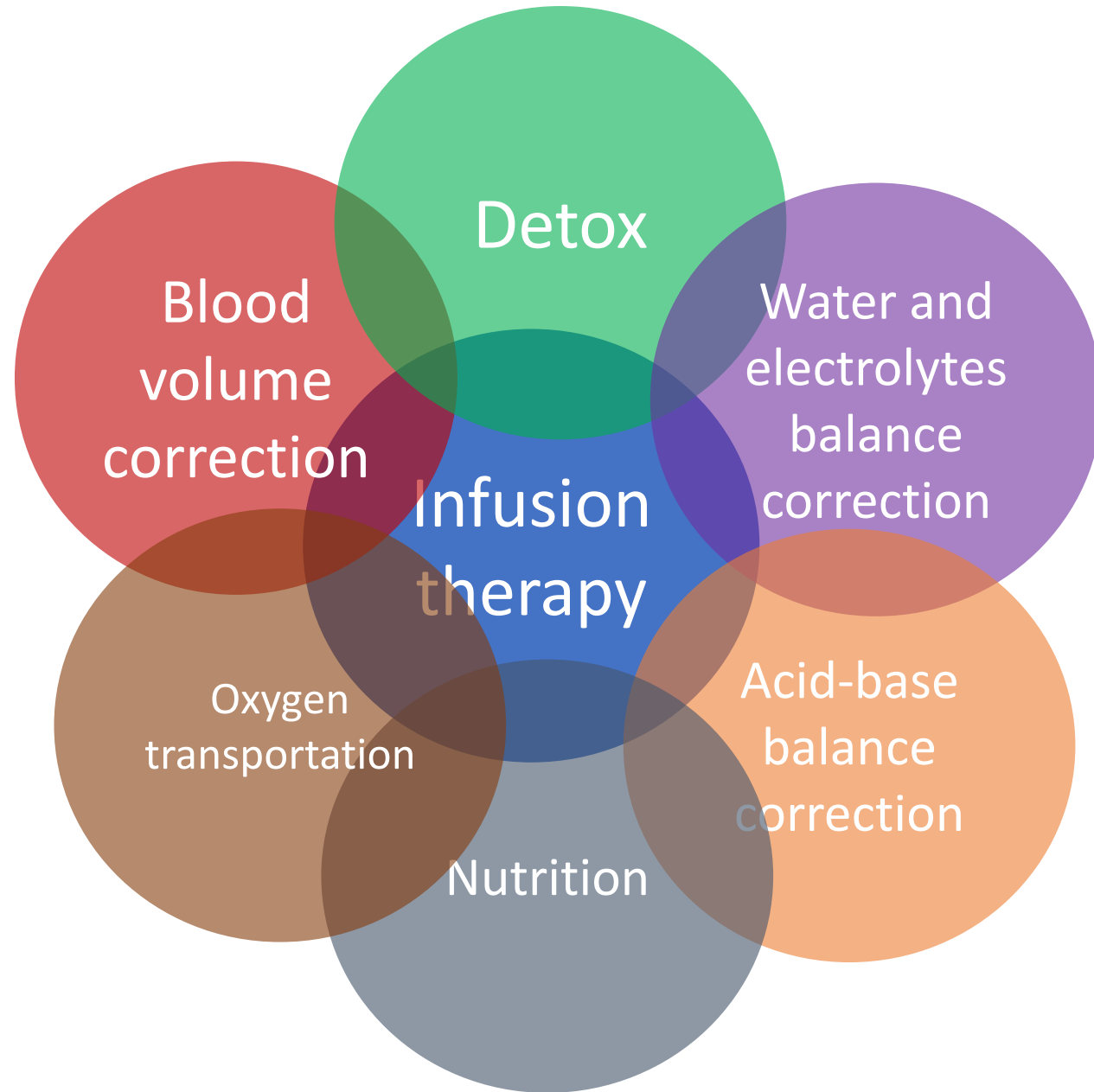
Hextend also contain magnesium 0.9 mmol/L and lactate 28 mmol/L.

Volulyte also contain magnesium 1.5 mmol/L and acetate 34 mmol/L.

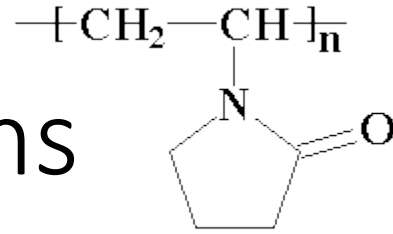
Solution	MW	pH	Osmolarity (mOsmol/L)	Osmotic pressure (mmHg)	Vc	Time of activity (hours)	Max dose (mL/kg)
Dextran 70	70 000	5,5	315	78	140	4-6	20
Dextran 40	40 000	5,5	300	160	170	3-4	12
Gelatin 20	20 000	6,8-7,4	430	20	60	1-2	40
Gelatin 30	30 000	7,1-7,7	274	33	100	3-4	200
Albumin 5%	66 000	6,5-7,0	290	22	80	1-2	25
Albumin 20%	66 000	6,5-7,0	290	90	400	1-2	10
Native plasma	?	5,5-7,0	290	33	100	1	20
NaCl 0,9%	134	5,5-7,0	308	5	20	0,5	?
HES 6%	200 000	4,0-7,0	300	30	100	3-4	33
HES 10%	200 000	4,0-7,0	300	50	145	5-6	20
Super HES 6%	450 000	4,0-7,0	300	30	100	6-8	20
HES	130 000	4,0-5,5	308	36	100	4-6	50
HES	130 000	4,0-6,5	309	30	100	4-6	50

Incidence for severe reactions for colloids





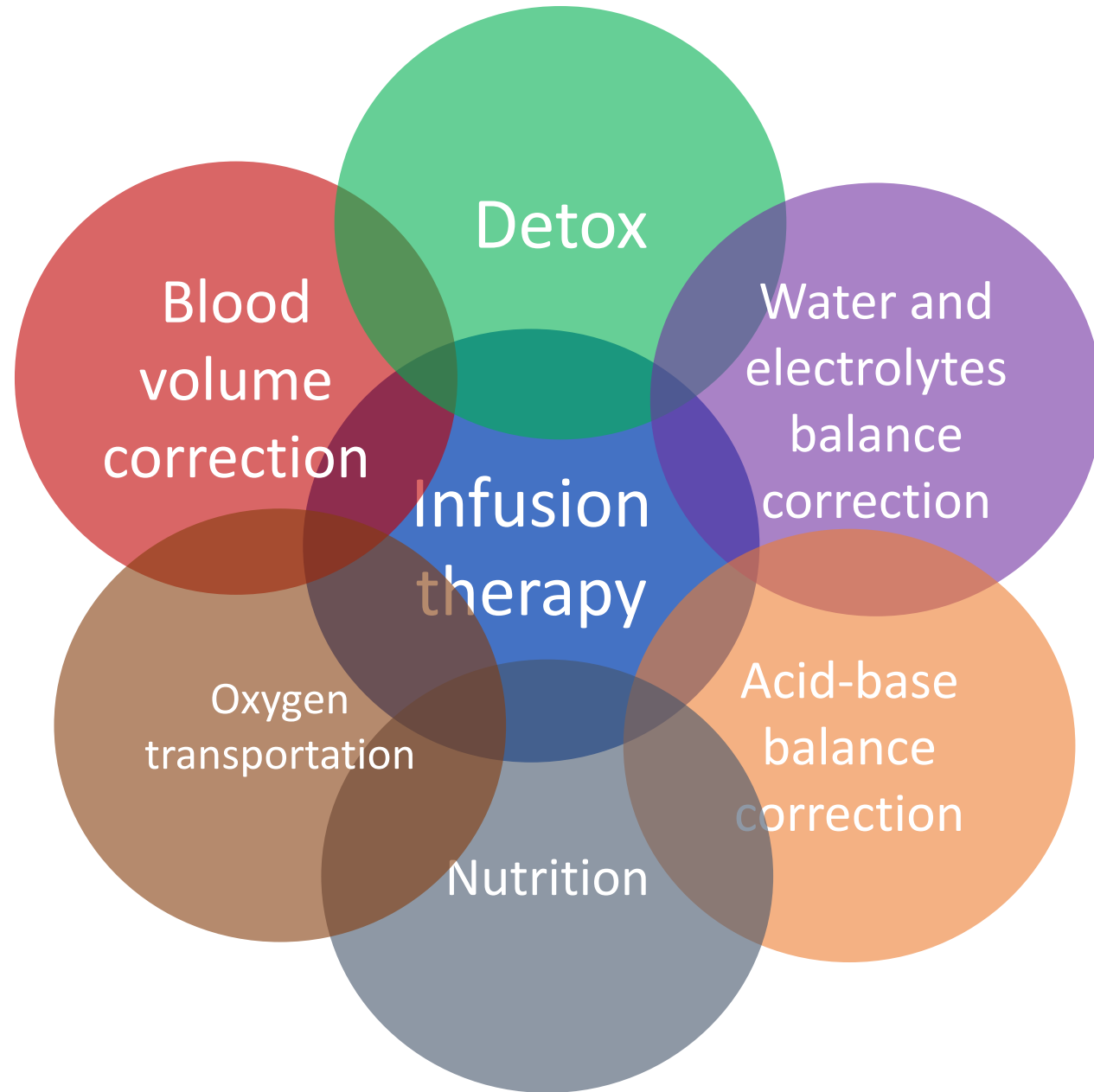
Detox solutions



- Adsorb and neutralize toxins
- Increase kidney blood flow
- Discharge of toxins with urine
- Preparations of polyvinylpyrrolidone
 - Gemodez, Polidez, Neohemodeus
- Molecular weight 10-30 kDa
- High risk of kidney failure
- **Up to date, excluded from a wide clinical application**

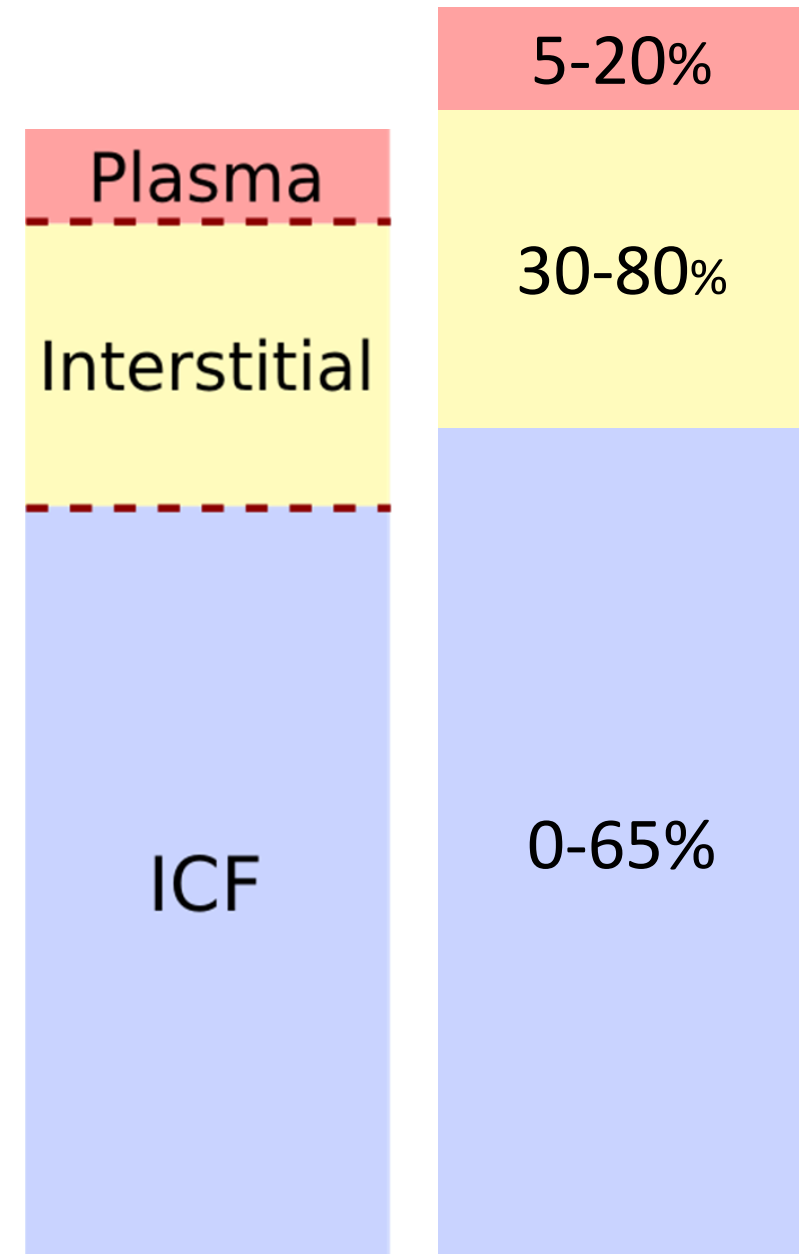
Isovolemic hemodilution with forced diuresis

- Modern method of detoxification
- Volume load with crystalloid solutions
- Reduction of toxins concentration due to hemodilution
- Intensification of diuresis
- Excretion of toxins with urine
- Crystalloid solutions with a volume of 2-3 liters with forcing diuresis with furosemide or mannitol to produce a volume of urine corresponding to the infusion load



Crystalloid solutions

- Solutions of inorganic ions and small organic molecules dissolved in water are referred to as crystalloids.
- Spread through all water compartment in different manner, slightly increase blood volume, low Vc
- Osmotic pressure:
 - Isotonic
 - Hypotonic
 - Hypertonic
- Ionic composition:
 - Non-balanced (NaCl 0,9%)
 - Balanced (Ringer's, Hartmann's etc)



Solution	Osmolarity mOsmol/L	pH	Na ⁺ mmol/L	Cl ⁻ mmol/L	K ⁺ mmol/L	Ca ²⁺ mmol/L	Glucose mg/L	HCO ₃ ⁻ mmol	Lactate mmol/L	Energy Kcal/L
Glucose 5%	252		-	-	-	-	50	-	-	400
Glucose 25%	1260		-	-	-	-	250	-	-	2000
Glucose 50%	2520		-	-	-	-	500	-	-	4000
Sodium Chloride 0.9%	308	5.0	154.0	154.0	-	-	-	-	-	-
Sodium Chloride and Glucose	264		31.0	31.0	-	-	40	-	-	320
Ringer's solution	309		147.0	156.0	4.0	2.2	-	-	-	-
Compound Sodium Lactate *	278		131.0	111.0	5.0	2.0	-	-	29.0	-
Plasmalyte B	298.5	5.5	140	98	5	-	-	50	-	-
Normasol+	280	7.4	140	98	5					

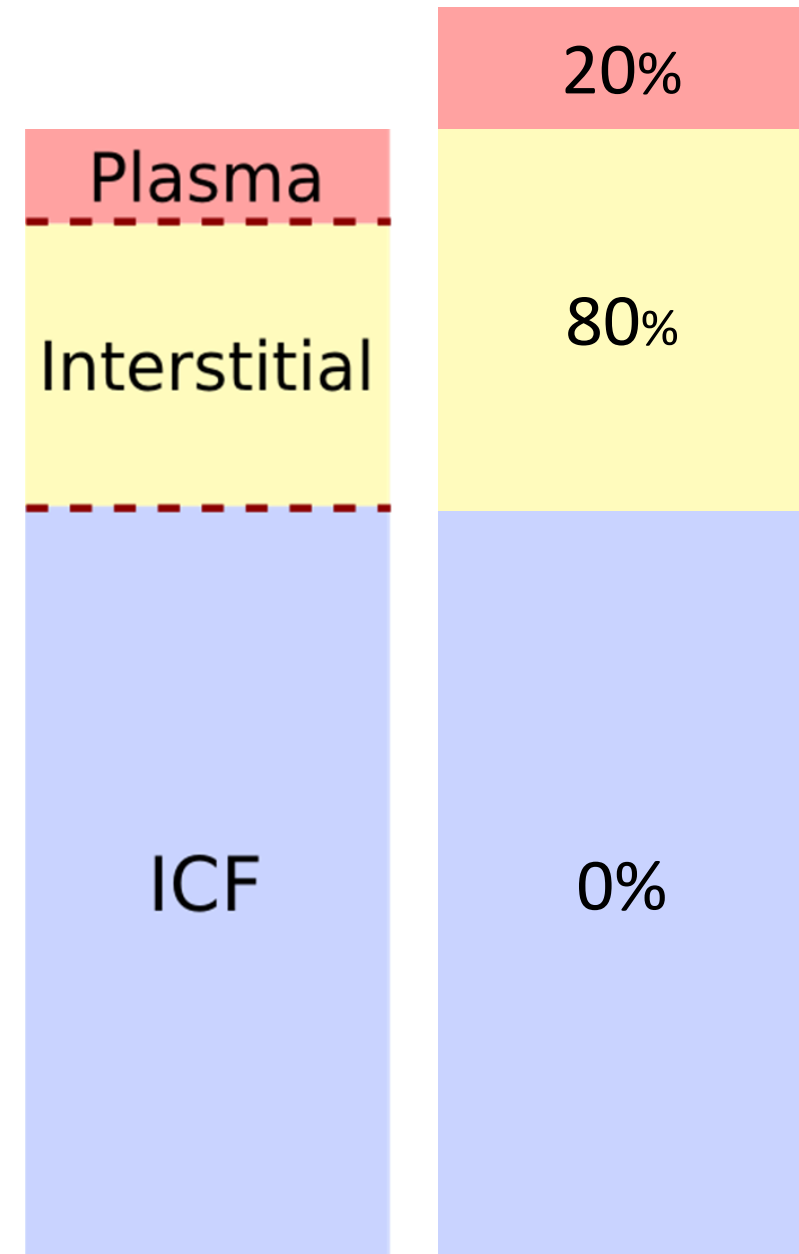
*Compound sodium lactate = Hartmanns' solution or Ringer's Lactate solution.

+Normasol contains acetate 27 mmol/L and gluconate 23 mmol/L

Normal osmolarity of plasma: 280-300 mOsmol/L

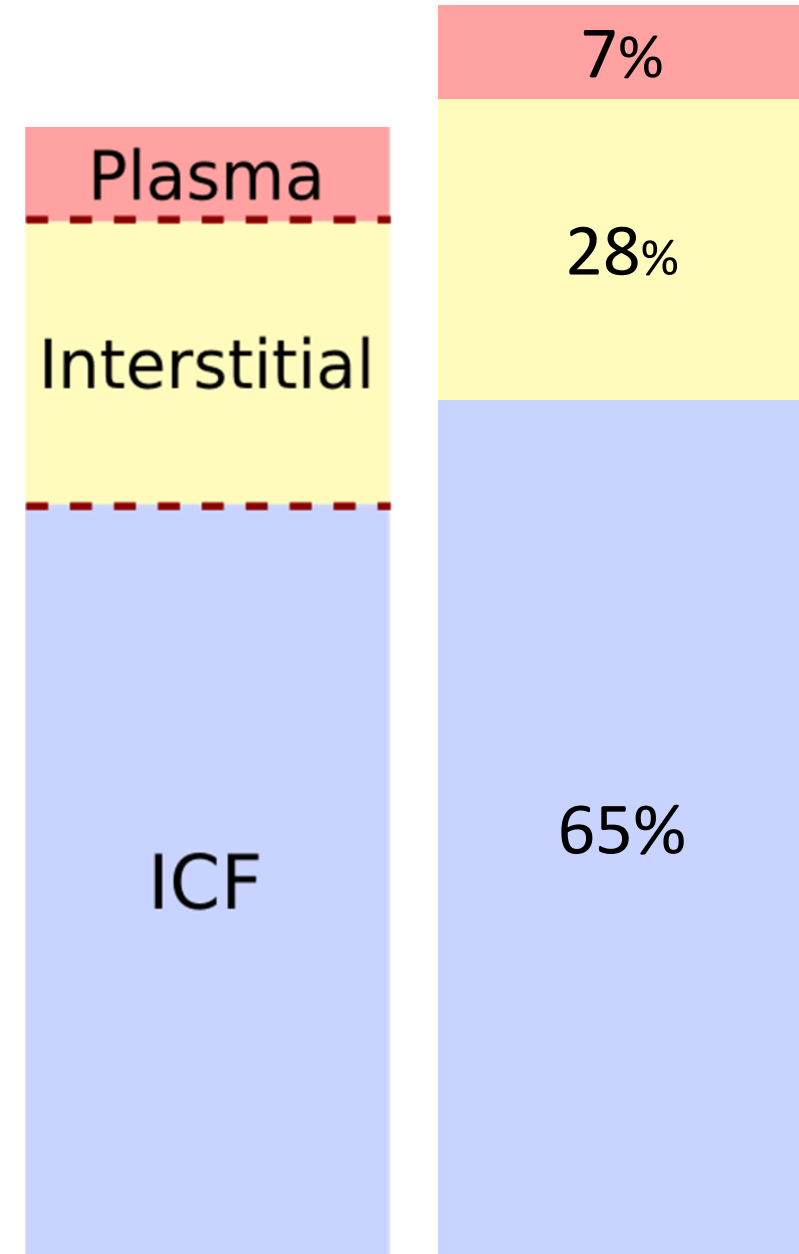
NaCl 0,9% (normal saline)

- Non-balanced
- Slightly hypertonic
- 70-80% of volume leave vascular space and move into interstitium ($V_c = 0,2-0,3$)
- Does not move into the cells and does not correct intracellular dehydration
- Lead to the hyperchloremic metabolic acidosis
 - Excretion of concurrent HCO_3^- to maintain the ionic balance



Isotonic glucose (5%)

- The small amount of glucose in the isotonic solution is rapidly metabolized allowing the solvent water to freely distribute throughout total body water.
- The glucose transport into the cells is insulin-dependent
- Isotonic glucose solution should be prescribed to treat simple dehydration and provide water replacement.
- When the rate of glucose utilization is exceeded (5 mg/kg/min), hyperosmolarity of the interstitium occurs that affects normal fluid transposition
- Increases the production of CO_2 and lactate (up to 85% in critical states)



Dextrose (D-glucose) – insulin-independent transport

Composition of common crystalloid solutions					
Solution	Other Name	[Na ⁺](mmol/L)	[Cl ⁻](mmol/L)	[Glucose](mmol/L)	[Glucose](mg/dl)
D5W	5% Dextrose	0	0	278	5000
2/3D & 1/3S	3.3% Dextrose / 0.3% saline	51	51	185	3333
Half-normal saline	0.45% NaCl	77	77	0	0
Normal saline	0.9% NaCl	154	154	0	0
Ringer's lactate	Lactated Ringer	130	109	0	0
D5NS	5% Dextrose, Normal Saline	154	154	278	5000

Effect of adding one litre		
Solution	Change in ECF	Change in ICF
D5W	333 mL	667 mL
2/3D & 1/3S	556 mL	444 mL
Half-normal saline	667 mL	333 mL
Normal saline	1000 mL	0 mL
Ringer's lactate	900 mL	100 mL

Crystalloid solutions

- The distribution of crystalloid solutions increases the risk of interstitial and intracellular edema, including pulmonary edema (ARDS), which limits their use in severe volemic disorders
- Tissue edema can compress capillaries and decrease oxygen delivery aggravating ischemia



Colloid or crystalloid?

- We identified 78 eligible trials; 70 of these presented mortality data.
- Critically ill patients with trauma, burns, following the surgery.
- COLLOIDS COMPARED TO CRYSTALLOIDS:
 - **Albumin or plasma protein fraction** - 24 trials reported data on mortality, including a total of 9920 patients. The pooled risk ratio (RR) from these trials was 1.01 (95% confidence interval (CI) 0.93 to 1.10) – **no difference**
 - **Hydroxyethyl starch** - 25 trials compared hydroxyethyl starch with crystalloids and included 9147 patients. The pooled RR was 1.10 (95% CI 1.02 to 1.19) – **increase mortality**
 - **Modified gelatin** - 11 trials compared modified gelatin with crystalloid and included 506 patients. The pooled RR was 0.91 (95% CI 0.49 to 1.72) - **no difference**
 - **Dextran** - nine trials compared dextran with a crystalloid and included 834 patients. The pooled RR was 1.24 (95% CI 0.94 to 1.65) - **no difference**
- COLLOIDS IN HYPERTONIC CRYSTALLOID COMPARED TO ISOTONIC CRYSTALLOID:
 - Nine trials compared **dextran in hypertonic crystalloid** with isotonic crystalloid, including 1985 randomised participants. Pooled RR for mortality was 0.91 (95% CI 0.71 to 1.06) - **no difference**

- Because of the risk of kidney injury and mortality, HES solutions must no longer be used in patients with **sepsis, burn injuries or critically ill patients**.
- HES solutions should only be used for the treatment of hypovolaemia due to acute blood loss when crystalloids alone are not considered sufficient.
- There is a lack of robust long-term safety data in patients undergoing surgical procedures and in patients with trauma. The expected benefit of treatment should be carefully weighed against the uncertainties with regard to long-term safety, and other available treatment options should be considered. Additional studies will be performed with HES solutions in patients with trauma and in elective surgery.
- HES solutions should be used at the lowest effective dose for the shortest period of time. Treatment should be guided by continuous haemodynamic monitoring so that the infusion is stopped as soon as appropriate haemodynamic goals have been achieved.
- HES solutions are now contraindicated in patients with renal impairment or renal replacement therapy. The use of HES must be discontinued at the first sign of renal injury. An increased need for renal replacement therapy has been reported up to 90 days after HES administration. Patients' kidney function should be monitored after HES administration.
- HES solutions are contraindicated in severe coagulopathy. HES solutions should be discontinued at the first sign of coagulopathy. Blood coagulation parameters should be monitored carefully in case of repeated administration.



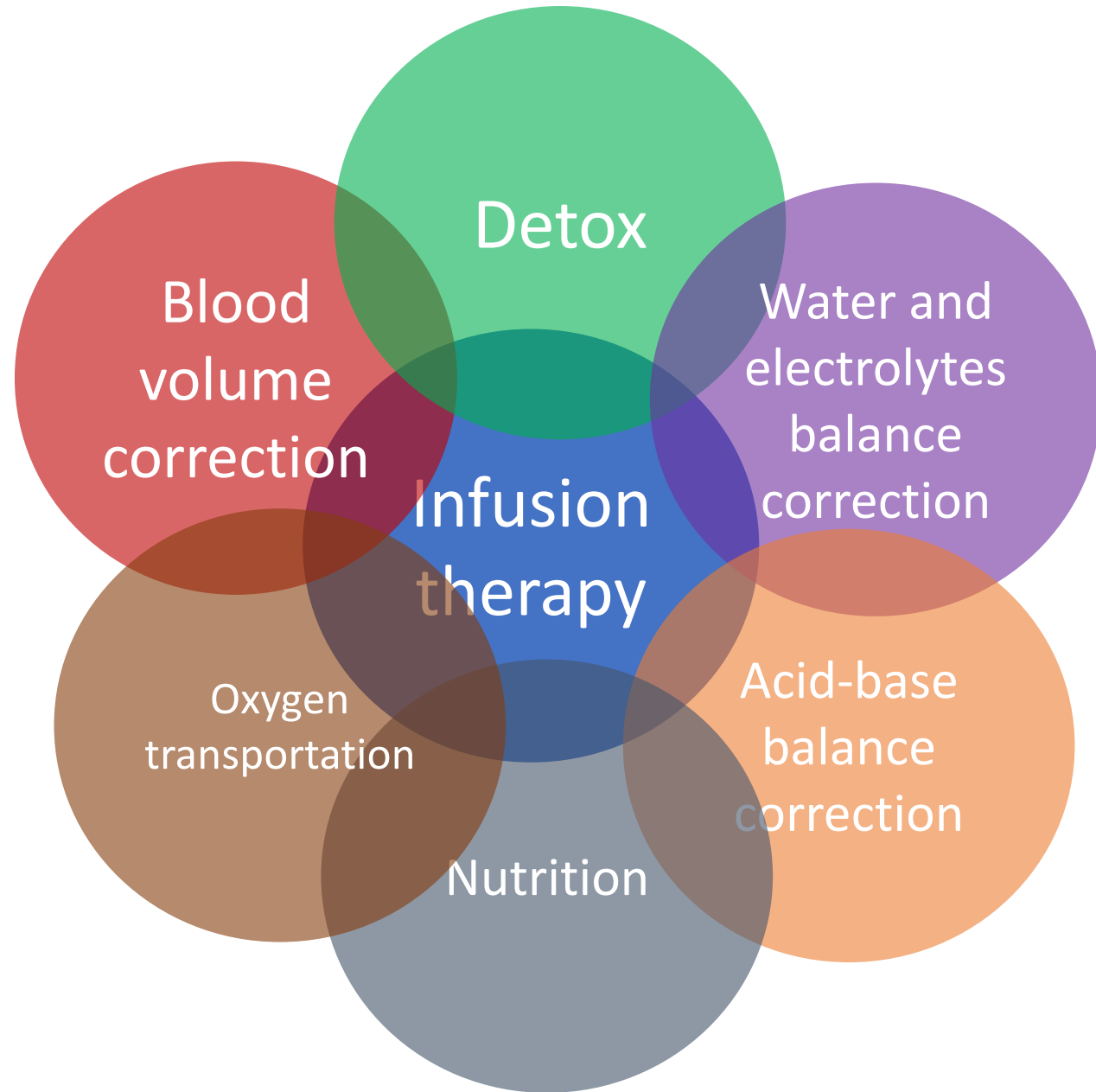
19 December 2013
EMA/809470/2013

Hydroxyethyl-starch solutions (HES) no longer to be used in patients with sepsis or burn injuries or in critically ill patients

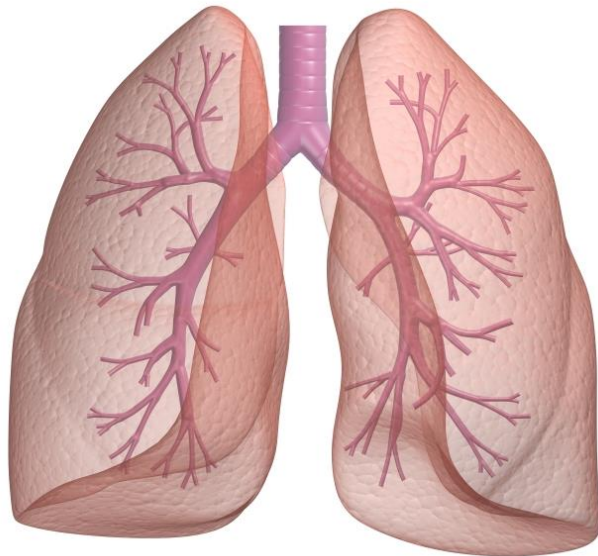
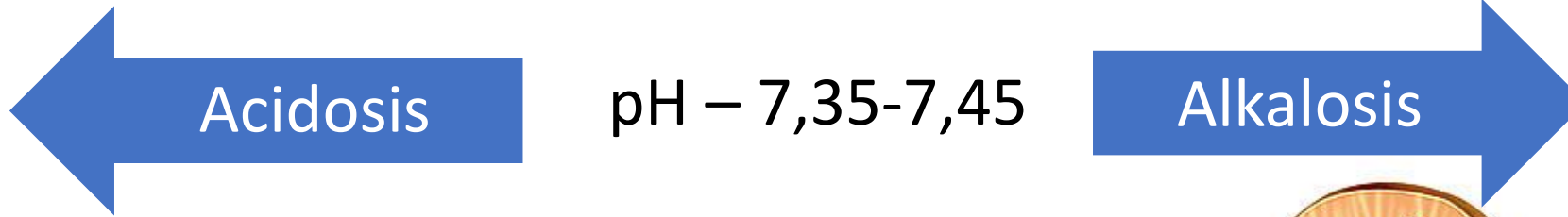
HES will be available in restricted patient populations

Balanced Crystalloids Versus Saline

- Thirteen studies (n = 30 950) were included.
- Balanced crystalloids demonstrated **lower hospital or 28-/30-day mortality** (risk ratio [RR] = 0.86; 95% CI = 0.75-0.99; I^2 = 82%) overall,
 - in observational studies (RR = 0.64; 95% CI = 0.41-0.99; I^2 = 63%),
 - in randomized trials (RR = 0.94; 95% CI = 0.88-1.02; I^2 = 0%).
- New acute kidney injury occurred **less frequently** with balanced crystalloids (RR = 0.91; 95% CI = 0.85-0.98; I^2 = 0%),
- Progression to renal replacement therapy was **similar** (RR = 0.91; 95% CI = 0.79-1.04; I^2 = 38%).
- In the sepsis cohort, odds of hospital or 28-/30-day **mortality were similar**, but the odds of major adverse kidney events occurring in the first 30 days were **less** with balanced crystalloids than saline (OR = 0.78; 95% CI = 0.66-0.91; I^2 = 42%).



Acid-base balance correction



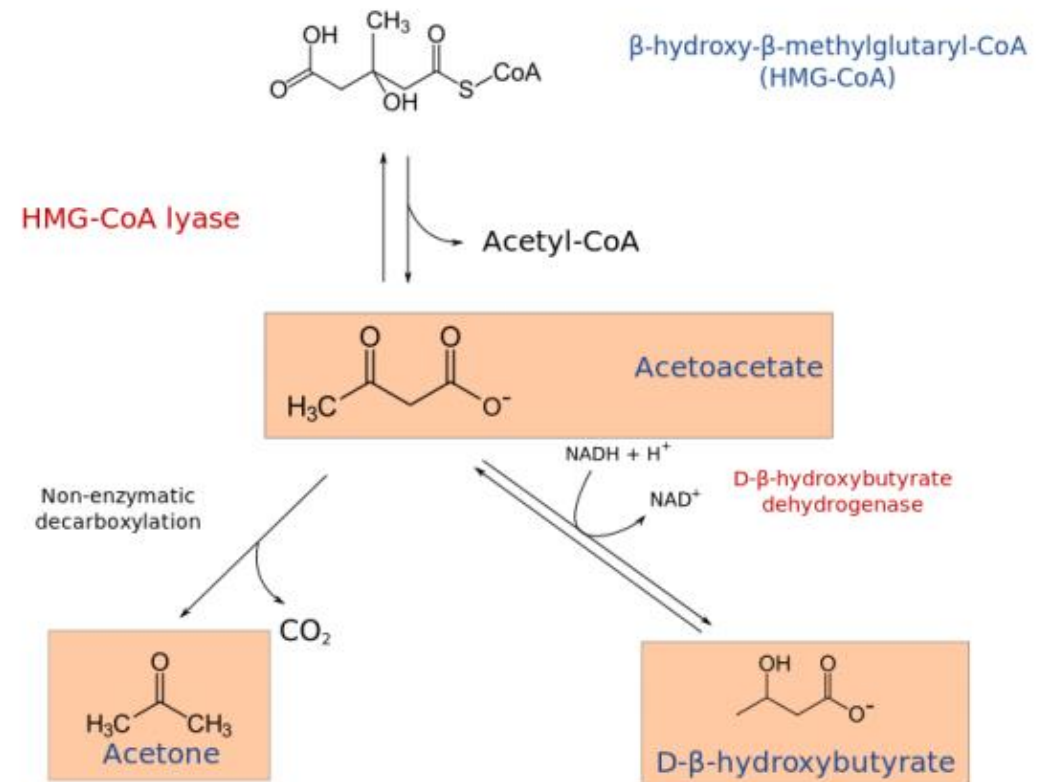
Metabolic:
 HCO_3^- (SB) – 24-28 mmol/L

Respiratory:
 pCO_2 35-45 mm Hg



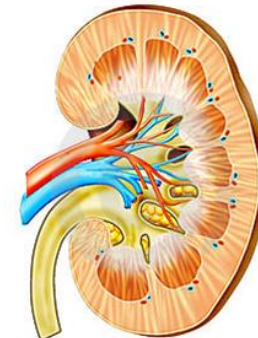
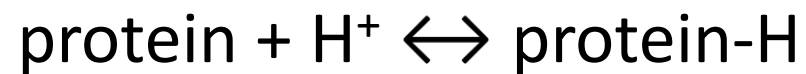
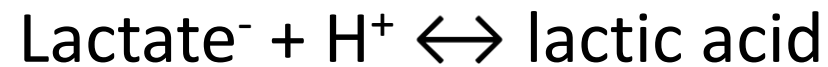
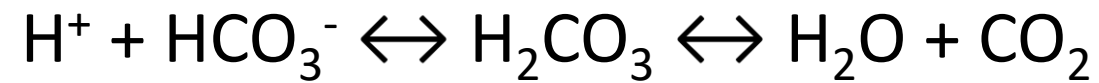
Metabolic acidosis

- Ketoacidosis (ketone bodies - acetoacetate, beta-hydroxybutyrate, acetone)
 - Diabetes
 - Alcohol Intoxication
 - Starvation
- Lactate Acidosis
 - Shock
 - Multi-organ dysfunction
 - Sepsis
 - Critical ischemia
 - Great seizures
 - Excess of vasopressors
- Hyperchloremic acidosis



Blood buffers

- Bicarbonate
- Phosphate
- Protein
- Hemoglobin



Acid-base balance correction

- Sodium bicarbonate (1000 mmol/L HCO_3^-)
- Carbicarb (333 mmol/L HCO_3^-)
- Sodium dichloroacetate (stimulates oxalic decarboxylation of pyruvic acid, is effective for lactic acidosis)
- Trometamol (trisamine)
- Hydrochloric acid

Indications for sodium bicarbonate

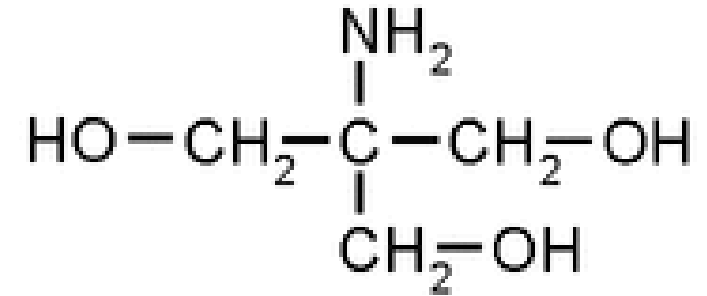
Metabolic acidosis

- $\text{pH} < 7,2$
- $\text{HCO}_3^- < 15 \text{ mmol/L}$
- Persistent hypotension, resistant to vasopressors

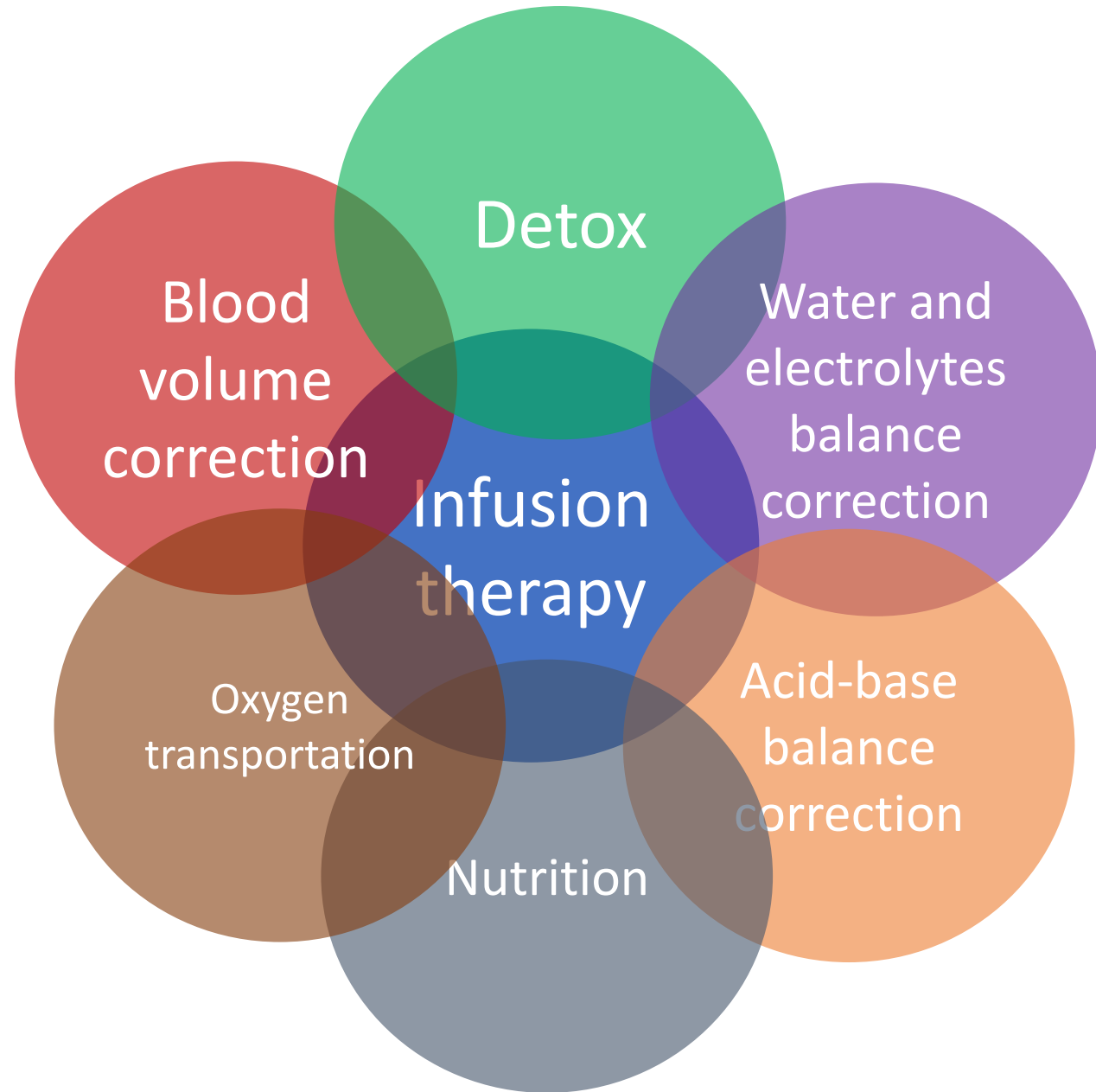
Limitations for sodium bicarbonate infusion

- Excess formation of CO_2
- Dependence of efficacy on lung function safety
- The development of intracellular acidosis (does not penetrate the cell, in contrast to the carbon dioxide that forms)
- Decreased level of extracellular calcium, decreased blood pressure and cardiac output
- Stimulation of erythrocytes to release lactate

Trometamol (trisamine)



- Binds H^+ , incl. bicarbonate buffer and evacuate them through the urine
- Stimulates diuresis due to osmotic activity
- Penetrates inside cells, stopping intracellular acidosis
- Increases the buffer base (BB)
- Can be used in both metabolic and respiratory acidosis (as part of complex therapy) because does not increase the concentration of CO_2



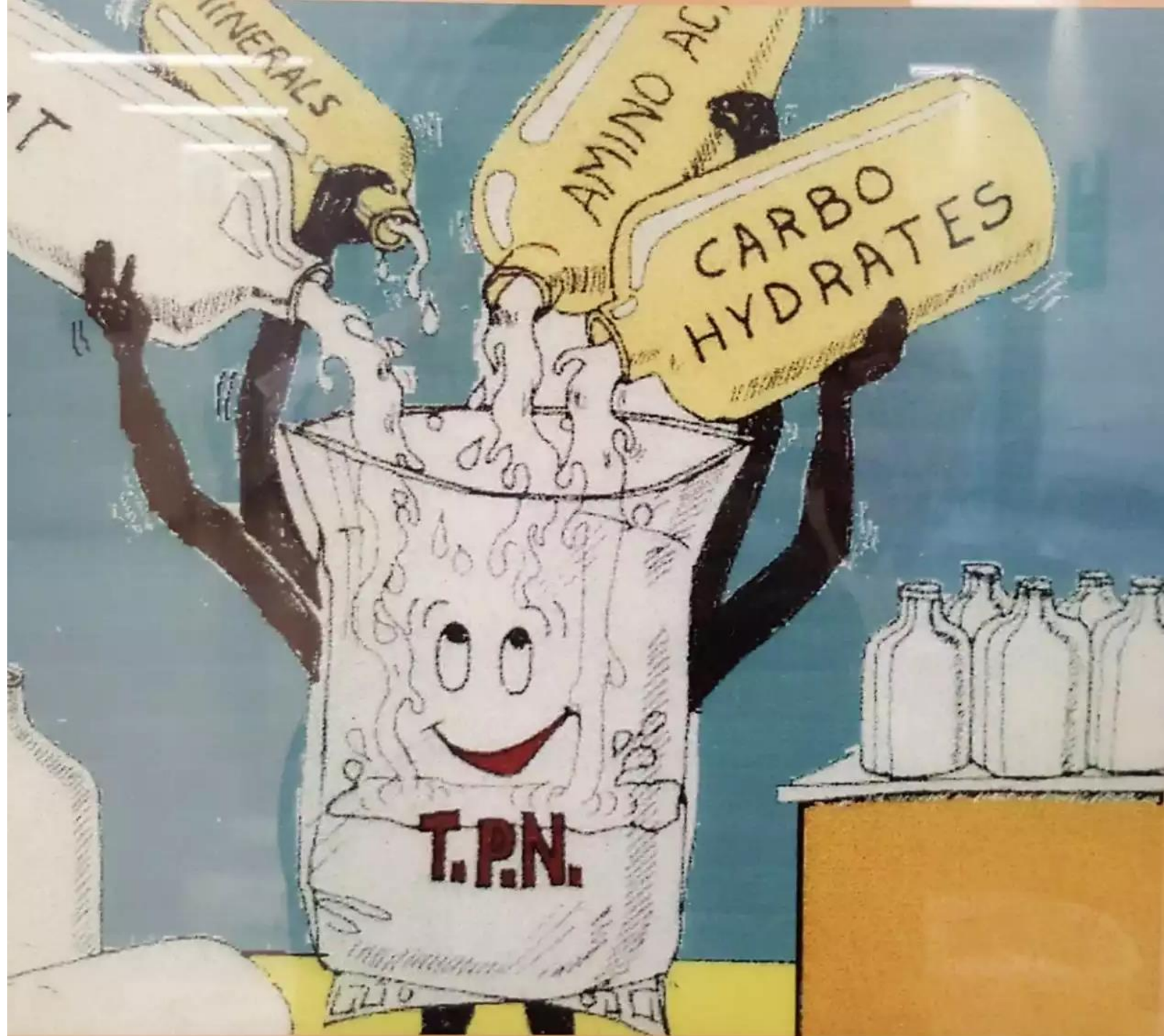


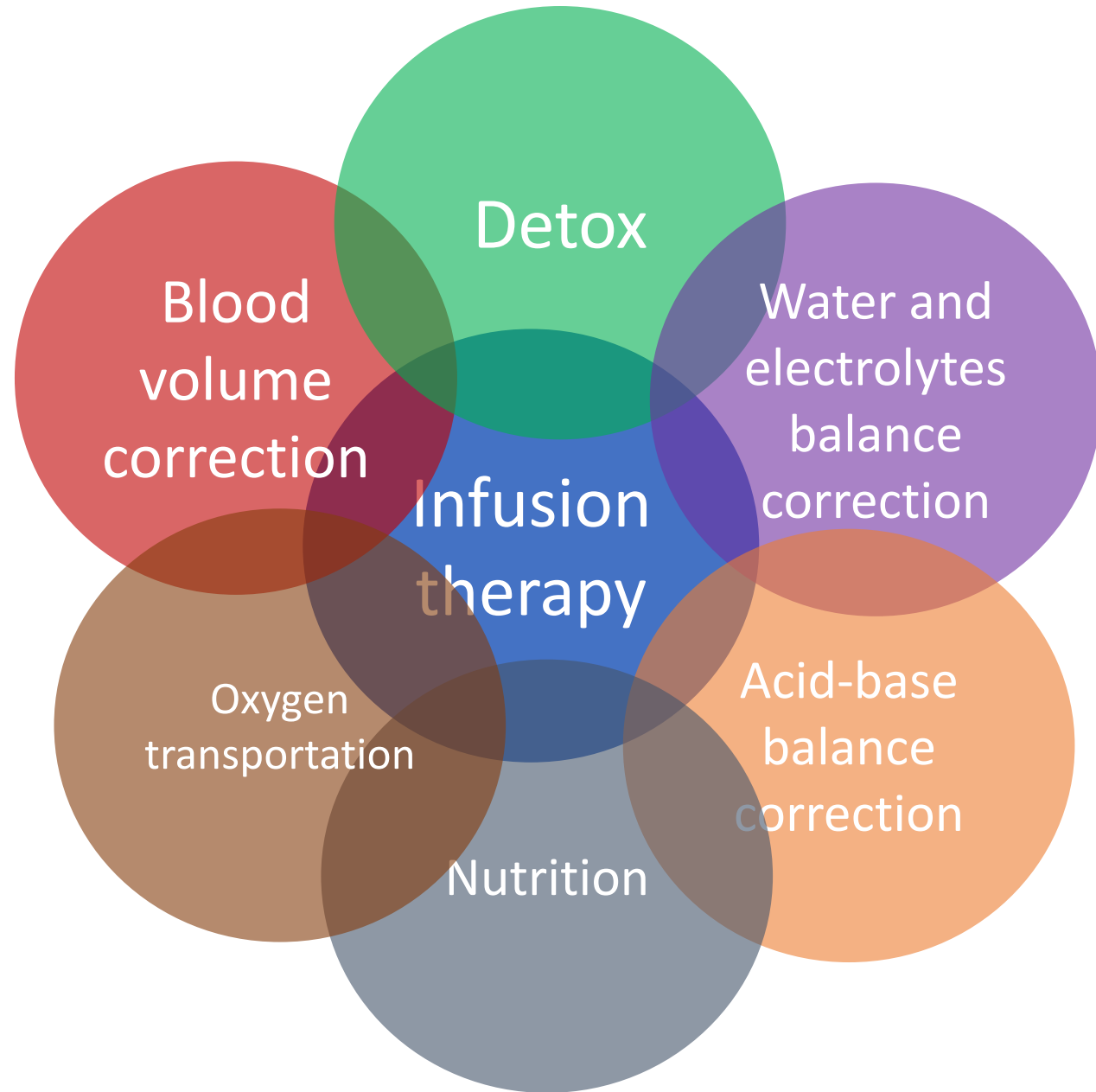
Parenteral nutrition

- Carbohydrates: 10%, 20%, 40% of glucose solution
- Fatty emulsions (lipofundin, intralipid)
- Mixtures of the amino acids (infusamin, polyamine)
- Ready-to-use mixtures

Parenteral nutrition

- Absolutely parenteral nutrition is indicated only in case of enteral insufficiency syndrome
- In other cases, parenteral nutrition is used in addition to enteral, with high plastic and energy needs of the body
- The needs of the body are determined by the initial nutritional status and the nature of the underlying pathology





Oxygen transporters

- Perftorans:
 - Alternative to blood transfusion
 - Improvement of microcirculation
 - Anti-shock effect
 - High price
 - Non-estimated efficacy





Oxygen transporters

- poly-HEME
 - Solution of human hemoglobin extracted from red blood cells that was modified using a multi-step polymerization process.
 - The purified hemoglobin was associated into tetramers and incorporated into an electrolyte solution in an attempt to reduce the side-effects of using non-polymerized hemoglobin such as vasoconstriction and renal failure.
 - Did not contain intact red blood cells which express ABO antigens, cross-matching of the product or typing of the patient was not necessary.
 - Shelf life of over twelve months and could be stored at room temperature
 - Limited circulation time require next transfusion of RBCs
 - Interferes with many laboratory tests, especially those measured spectrophotometrically
 - It has been associated with an increased risk of myocardial infarction (heart attack)



How much water
do you need?

Daily demand for water

Water intake		Water lose	
Food	2100	Diuresis	1500
Endogenic water	300	Sweating	450
		Breath	350
		Feces	100
Totally	2400	Totally	2400

Basic fluid requirement 30 ml / kg / day
≈2100 ml

Daily infusion volume

Daily infusion volume:

Basic requirement
(30 mL/kg/day)

+

correction of existing
violations

+

current daily loss

Isotonic status:

Glu/Dex 5% : saline = 2 : 1

Hypertonic status:

Glu/Dex 5% : saline = 4 : 1

Hypotonic status:

Glu/Dex 5% : saline = 1 : 1

Infusion program

To improve the utilization of glucose for every 5 grams of dry residue, 1 unit of insulin:

- 400 5% solution - 20 g dry residue - 4 units of insulin
- 400 10% of the solution - 40 g of dry residue - 8 units of insulin
- The composition of salt solutions is determined by the nature of the losses and must contain all the necessary electrolytes (for example, trisol in intestinal losses or $\text{NaCl} + \text{KCl} + \text{NaHCO}_3$ or lactate or acetate)

The nature of losses from the digestive tract

Fluid	Mean Volume (ml/24h)	Electrolytes concentration (mmol/l)			
		Na+	K+	Cl-	HCO ₃
Plasma		136-145	3,5-5,5	98-106	23-28
Stomach juice	2500				
With HCl		10-110	1-32	8—55	0
Without HCl		8 — 120	1—30	1000	20
Bile	700-1000	133-156	3,9-6,3	83-110	38
Pancreatic juice	1000	113-153	2,6-7,4	54-95	110
Intestinal juice	3000	72-120	3,5—6,8	69— 127	30
Fresh ileostomy	100-4000	112—142	4,5—14	93—122	30
Old ileostomy	100-500	50	3	20	15-30
Cecostomy	100-3000	48-116	11,1—28,3	35-70	15
Feces	100	10	10	15	15
Sweat	500-4000	30-70	0-5	30-70	0