In The Name Of Allah
The Compassionate , The Merciful

Perioperative Fluid & Electrolyte Therapy
Part 2

M.Masjedi MD
Associate Prof. of anesthesia ,
critical care consultant

Miller's anesth.,2020

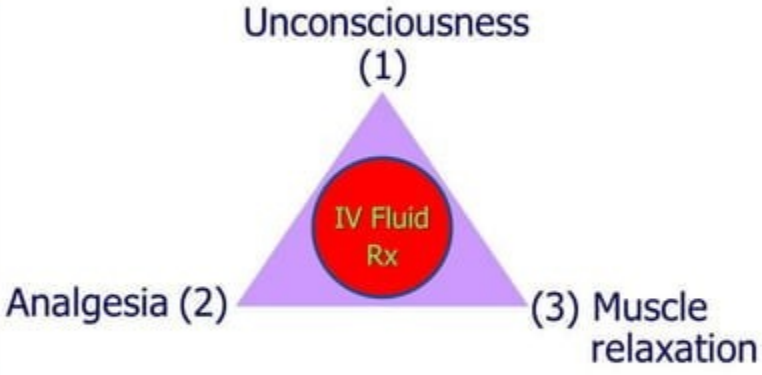
Anesthesia Grand Round , SUMS
Nov 26th , 2019



We are approximately two-thirds water

The triad of balanced general anaesthesia

Traditional triad



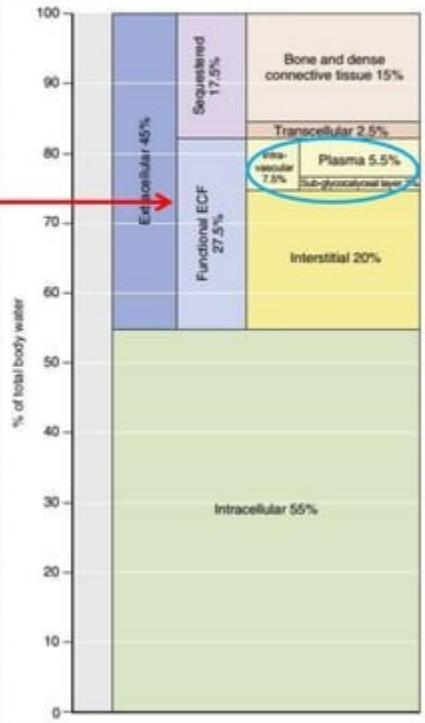
Objectives:

- ✓Review of part 1
- ✓Types of Intravenous fluids
- ✓Physiologic insult of periop. Period
- ✓Which & How much Fluid
- ✓How to guide periop. fluid Rx


KEEP
CALM
AND
LET'S
REVIEW
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Total-body water (intracellular and extracellular)

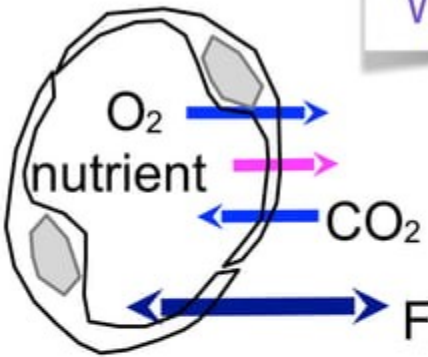
- Extracellular fluid (functional ***v/s*** sequestered)
- Functional :
  - A. Interstitial fluid (ISF):
    1. Lymphatic fluid
    2. protein poor fluid occupying cell spaces
  - B. Intravascular fluid: Plasma volume, including subglycocalyx
- Sequestered:
  - A. Transcellular fluid: GI tract fluid, bile, urine, csf , aqueous humor, joint fluid, pleural , peritoneal & pericardial fluid (functionally important , varying composition & regulated by active cellular transport)
  - A. Water in bone and dense connective tissue

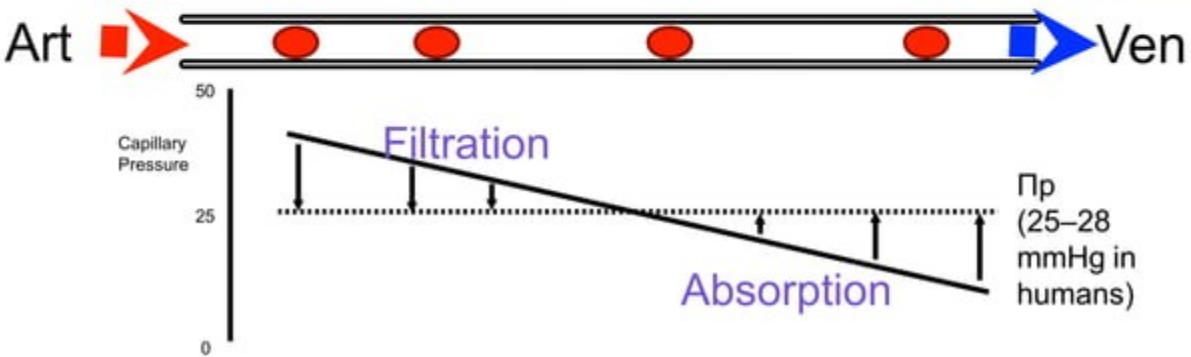


What we were all taught…

Starling law





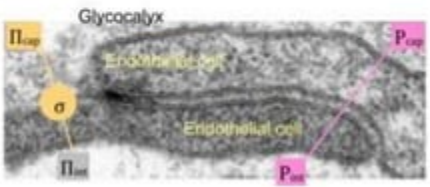


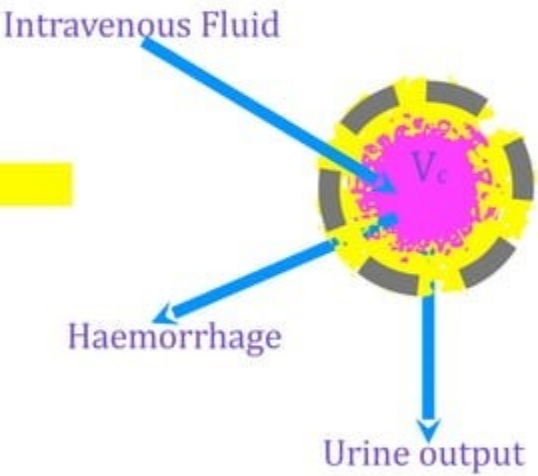
What we teach now...

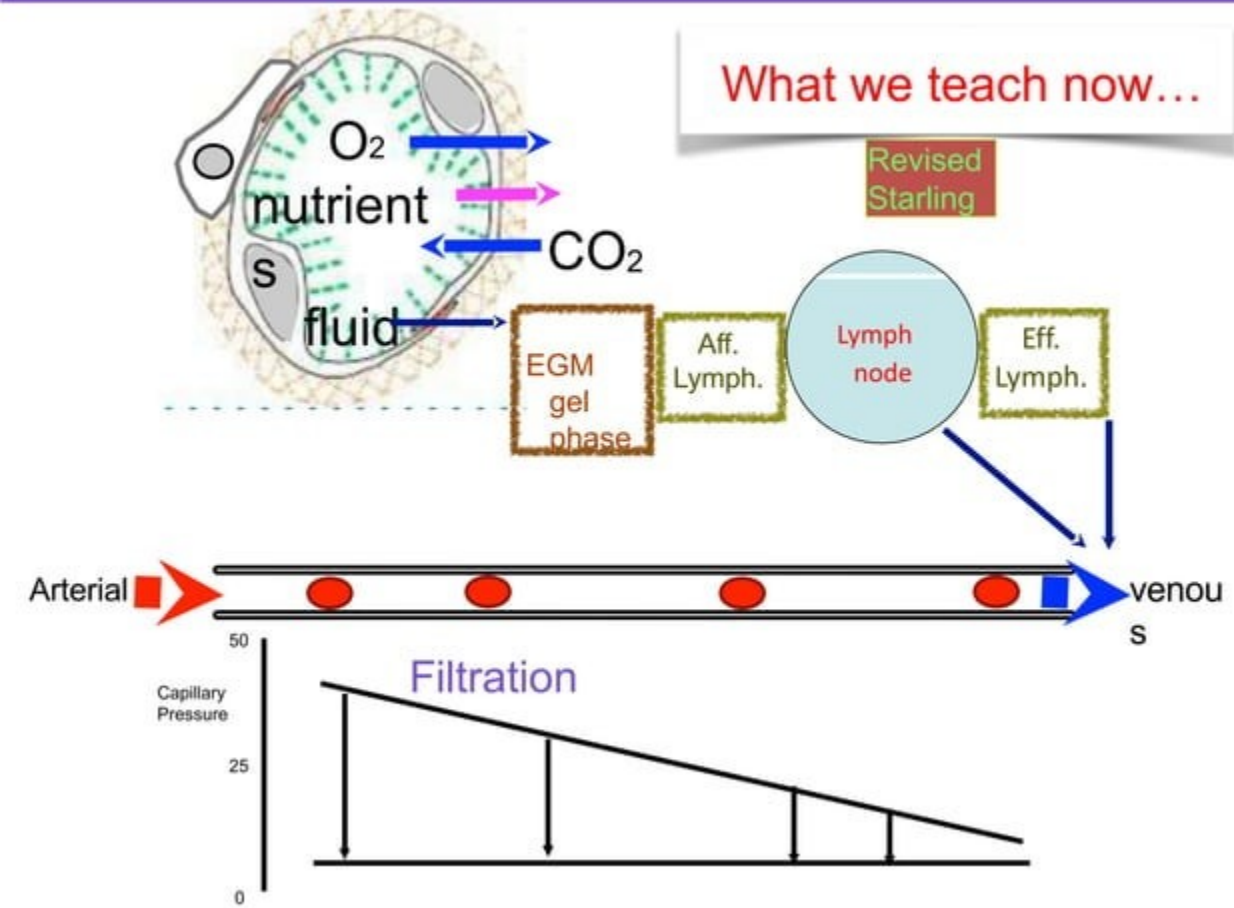
Intravascular fluid exists in ***2 forms***;

1. The free-flowing plasma

2. Endothelial glycocalyx layer (EGL)






What we teach now…
Revised Starling
O2
nutrient
s
fluid
CO2
EGM gel phase
Aff. Lymph.
Lymph node
Eff. Lymph.
Arterial
venous
50
Capillary Pressure
25
0
Filtration

What we teach now…

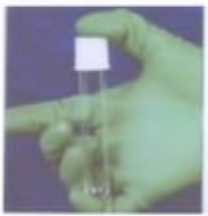
Crystalloid Vs Colloid Intravas. Vol. Effects

- Crystalloid → one fourth or one fifth of vol. within blood
- Colloids → remain largely within intravas vol.



based on RBC dilution & changes in htc **not** SGL vol.



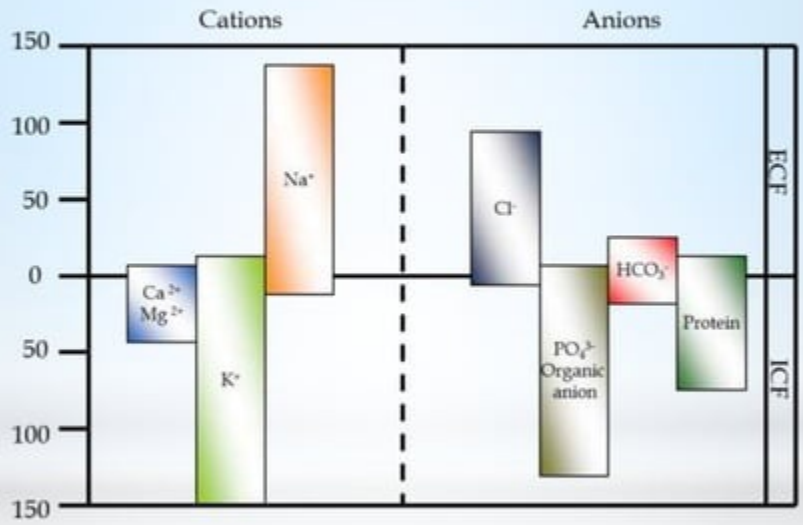


≠



- **Colloids remain in plasma → diluting effect on htc → appear to remain** in circulation
- **Crystalloids** , in **plasma and SGL** → lower RBC dilutional effects → **appear to leave** circulation & entering ISF (remain in blood vol. within SGL)

Electrolyte Physiology




B.A.A.
1040

ACID-BASE DISTURBANCES & FLUID THERAPY

- IVF Rx may affect acid-base balance:

1. **Iatrogenic acidosis** caused by administration of **Cl−** rich fluids

2. Administration of **sodium bicarbonate** to correct acidosis

ACID-BASE DISTURBANCES & FLUID THERAPY

Stewart's approach : plasma **pH** is dependent on **3** **independent variables**:

1. **PCO2** (the plasma CO2 tension)
2. **Atot** , total plasma concentration of **all nonvolatile buffers** (albumin, globulins, and PO43−)
3. **Strong ion difference (SID), difference** between **total** charge of **plasma-strong cations** (Na+, K+, Mg2+, and Ca2+) and **strong anions** (Cl−, lactate, sulfate, and others)

- ✓ More simplified , Apparent SID = ([Na+] + [K+]) – ([Cl−] + [lactate])
- ✓ **Normal plasma SID ≈ 42 mEq/L**
- ✓ ↓SID → ↓plasma pH

Stewart's model

- Hyperchloremic Acidosis

✓ **0.9% saline** → metabolic acidosis due to the Cl− content

↑plasma Cl− → ↓apparent SID →↓ pH

✓ Not seen with **lactated Ringer solution**

***in vitro* SID = zero**

lactate metabolism → **in vivo** SID ≈ **29** mEq/L

ACID-BASE DISTURBANCES & FLUID THERAPY

- **Saline-induced hyperchloremic acidosis** → deleterious physiological effects
  - renal vasoconstriction
  - ↓ GFR
  - ↓ renin activity in
- Although these trials did not relate specifically to the perioperative setting, an increasingly *cautious approach to saline* administration seems appropriate
- hyperchloremia → ↑**morbidity ?**
- Recent large trials in ER & ICU :

  ↑death or adverse renal event with saline vs balanced crystalloid

  (The effect is greatest in sepsis)

ACID-BASE DISTURBANCES & FLUID THERAPY



Bicarbonate Administration

- For **emergency Rx of** selected conditions:
  - **severe hyperkalemia**
  - **arrhythmias of TCA** overdose

- **Acidosis** in itself **may *not* be deleterious**;
  NI during strenuous exercise, **aid O2 offloading** to tissues

- **Acidosis** : **a marker** of underlying dis. (**hypoxia, ischemia, or mitochondrial dysfunction**, which cause morbidity without adequate correction)

Acid-base Disturbances & Fluid Therapy



Bicarbonate Administration - **negative effects**:

1. **Carbon dioxide production** ($HCO_3^- \rightarrow CO_2$) , two consequences
   I. ↑**CO_2** → necessitates **hyperventilation** ([redacted])
   II. CO_2 diffuses into intracellular space→ ↑**intracellular acidosis**

2. A **significant Na+ content → osmotic load**
   - ✓ hyperosmolar hypernatremia
   - ✓ ECF expansion
   - ✓ vol overload

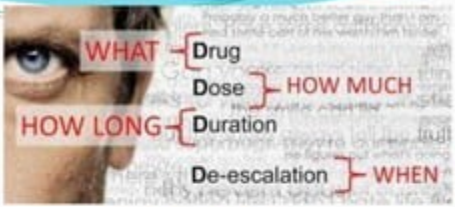
3. Possibility of **"overshoot" metabolic alkalosis** (once acidosis is resolved)

Required Bicarbonate:

[redacted]

- ➢ half of this dose is given (above problems)
- ➢ Stop if pH ≥ 7.2

Fluid Pharmacology



Fluids are drugs with specific **indications, cautions & side effects**

- Many fluids developed **several decades ago**,
  entered **clinical practice without rigorous analysis** of
  their effects @ organ or cellular level ???!!!

- **Newer colloid**s :
  entered **widespread** clinical usage
  based on small trials of efficacy ???!!!

TABLE 47.6 Composition of Fluids Available for Intravenous Administration*

Fluid	Sodium	Potassium	Chloride	Calcium	Magnesium	Bicarbonate	Lactate	Acetate	Gluconate	Glucose (g/L)†	Other	Osmolarity	Notes	pH (In Vitro)
Plasma	140	5	100	4.4	2	24	1	—	—	—	—	285	SID 42	7.4
0.9% NaCl	154	—	154	—	—	—	—	—	—	—	—	308	SID 0	6.0
1.8% NaCl	308	—	308	—	—	—	—	—	—	—	—	616		
0.45% NaCl	77	—	77	—	—	—	—	—	—	—		154		
5% dextrose	—	—	—	—	—	—	—	—	—	50		252		4.5
5% dextrose/0.45% NaCl	77	—	77	—	—	—	—	—	—	50		406		4.0
4% dextrose/0.18% NaCl	33	—	33	—	—	—	—	—	—	40		283		
Lactated Ringer solution (U.S. composition)	130	4	109	3	—	—	28	—	—	—		273		6.5
5% dextrose in lactated Ringer solution	130	4	109	3	—	—	28	—	—	50		525		5.0
Hartmann solution/compound Na^+ lactate	131	5	111	4	—	—	29	—	—	—		275	Involves SID 27	6.5
Plasma-Lyte 148/ Normosol-R	140	5	98	—	3									
Plasma-Lyte 56 and 5% dextrose/ Normosol M with 5% dextrose	40	13	40	—	3									
Plasma-Lyte A pH 7.4	140	5	98	—	3									
Sterofundin	140	4	127	5	2									
Plasma-Lyte R	140	10	103	5	3									
Hemosol	140	—	109.5	3.5	1									
4%-5% albumin	†	—	†	—	—									
20% albumin	†	—	†	—	—									
Plasmanate: Plasma protein fraction (human) 5%	145	0.25	100	—	—									

TABLE 47.6 Composition of Fluids Available for Intravenous Administration*—cont'd

Fluid	Sodium	Potassium	Chloride	Calcium	Magnesium	Bicarbonate	Lactate	Acetate	Gluconate	Glucose (g/L)†	Other	Osmolarity	Notes	pH (In Vitro)
Gelofusine (4%)	154	—	125	—	—	—	—	—	—	—	MWw 30 kDa		Succinylated gelatin	
Plasmion/Gelofusine (3%)	110	5	100	—	3	—	30	—	—	—	MWw 30 kDa		Succinylated gelatin	
Isoplex (4%)	145	4	105	—	1.8	—	25	—	—	—	MWw 30 kDa		Succinylated gelatin	
Gelaspan (4%)	151	4	103	2	2	—	—	24	—	—	MWw 30 kDa			
Haemaccel (polygeline)	145	5.1	145	12.5	—	—	—	—	—	—	MWw 35 kDa			
Voluven: Waxy maize HES 6% (130/0.4)	154	—	154	—	—	—	—	—	—	—		308		
Venofundin: Potato HES 6% (130/0.42)	154	—	154	—	—	—	—	—	—	—				
Hetastarch: Waxy maize HES 6% (670/0.75)	154	—	154	—	—	—	—	—	—	—		309		5.5
Hextend: Waxy maize HES 6% (670/0.75)	143	3	124	5	1	—	28	—	—	—				
Pentaspan: Pentastarch 10%	154	—	154	—	—	—	—	—	—	—	MWw 264 kDa	326		5.0
Volulyte: Waxy maize HES 6% (130/0.4)	137	4	110	—	3	—	—	34	—	—		287		
Plasma volume: Potato HES 6% (130/0.42)	130	5.4	112	1.8	2	—	—	27	—	—				
Tetraspan: Potato HES 6% (130/0.42)	140	4	118	5	2	—	—	24	5	—				
10% Dextran 40	—	—	—	—	—	—	—	—	—	50		255		4.0

Fluid Pharmacology
Crystalloids





- **Crystalloids** are solutions of **electrolytes in water**
- **Balanced solutions** are [redacted]
  1. [redacted]
  2. [redacted]
- **Classified** by their
  1. **Tonicity** after infusion
  2. **Composition**
- Indications:
  1. **Replacement** of free water & electrolytes
  2. **Vol. expansion !** (may be used)



Fluid Pharmacology
Crystalloids



- **Conventional** concepts :
  infused **electrolytes** will **distribute** freely **in ECF**,
  water will follow down osmotic gradients,
  only **20% remain intravascular**

- **Current** knowledge :
  Isotonic crystalloids have a **larger intravas vol expanding effect**
  particularly in pts with low capillary hydrostatic pressures

- Up to **70% remains** intravas **@ 20 min.**,
  decreasing to **50% after 30** min.

Fluid Pharmacology
Crystalloids



- **Tissue edema** in compliant tissues e.g. **lung, gut & soft tissues**

- **Large-volume crystalloid infusions** may cause **hypercoagulable state** caused by dilution of circulating anticoagulant factors (clinical significance?)

Fluid Pharmacology
Crystalloids



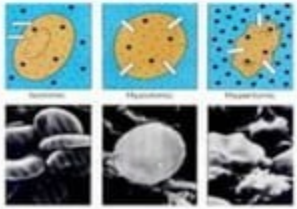
Saline Solutions

- One of the **most commonly administered** crystalloids is **0.9% NaCl**
- **In vitro RBC lysis** experiments : **0.9% NaCl , isotonic with human plasma**
- **Not** initially developed **for in vivo** , yet entered widespread clinical use **despite having a Na+ and Cl− concentration far in excess of that of plasma ???!!!**
- Both ions remain in ECF, **it is isotonic**

(**Similar *effective osmolarity* to plasma** with respect to cell membrane)







Fluid Pharmacology
Crystalloids



Saline Solutions

- 2-Lit 0.9% NaCl leads to :
  - ❖
  - ❖
  - ❖
  - ❖





- **Expansion** of ***ECF*** **persists >>** balanced crystalloid solutions
- **Both** fluids **induce diuresis**, 0.9% NaCl has a **later** onset
- Salt & water **load** : **multiple days to be excreted**

Fluid Pharmacology / Crystalloids /Saline Solutions

Compelling indications

Hypertonic Saline **(**1.8%, 3%, and 7.5%)



1. **Plasma vol. expansion** while **minimizing vol** of fluid administered
   - for **trauma** resuscitation, esp. in prehospital phase**???**

2. Correction of **hypoosmolar hyponatremia**

3. **Rx of ↑ICP :**
   1. ↑plasma osmolality→↓cereb edema & ↓ICP (superior to mannitol)
   2. **In TBI without knowledge of ICP ???**

Fluid Pharmacology / Crystalloids

Balanced Crystalloid Solutions



- **Crystalloids** first used for Rx of **cholera** in **1832** by O'Shaughnessy & Latta
- **Early solutions** were **more physiologic** than NaCl solutions
  (e.g:134 mEq/L Na+, 118 mEq/L Cl−, and 16 mEq/L HCO3−)
- Clinical interest waned until **Hartmann** in **1932** used **a lactated modification of Ringer** solution for pediatrics

TABLE 47.6 Composition of Fluids Available for Intravenous Administration[a]

Fluid	Sodium	Potassium	Chloride	Calcium	Magnesium	Bicarbonate	Lactate	Acetate	Gluconate	Glucose (g/L)[-1]	Other	Osmolarity	Notes	pH (In Vitro)
Plasma	140	5	100	4.4	2	24	1	—	—	—	—	285	SID 42	7.4
0.9% NaCl	154	—	154	—	—	—	—	—	—	—	—	308	SID 0	6.0
1.8% NaCl	308	—	308	—	—	—	—	—	—	—	—	616		
0.45% NaCl	77	—	77	—	—	—	—	—	—	—		154		
5% dextrose	—	—	—	—	—	—	—	—	—	50		252		4.5
5% dextrose/0.45% NaCl	77	—	77	—	—	—	—	—	—	50		406		4.0
4% dextrose/0.18% NaCl	33	—	33	—	—	—	—	—	—	40		283		
Lactated Ringer solution (U.S. composition)	130	4	109	3	—	—	28	—	—	—		273		6.5
5% dextrose in lactated Ringer solution	130	4	109	3	—	—	28	—	—	50		525		5.0
Hartmann solution/compound Na+ lactate	131	5	111	4	—	—	29	—	—	—		275	In vivo SID 27	6.5



Balanced Crystalloid Solutions

- ✓ **Osmolarity** = **274** mOsm/l (< 0.9% NaCl)
- ✓ **lower Na+** & much lower **Cl−**
- ✓ ↓**Anions compensated by** organic anionic buffers (**lactate, gluconate or acetate**)
- ✓ **Osmolality : 265** mOsm/kg ; slightly < plasma (mildly hypotonic)
- ✓ Fluid compartment **distribution** = **other crystalloids**

Balanced Crystalloid Solutions

Buffer is metabolized **to HCO3−** by entry into citric acid cycle

1. **Lactate** : **hepatic** oxidation or gluconeogenesis to yield HCO3−
2. **Acetate** : rapidly oxidized by **liver, muscle & heart** to yield HCO3−
3. **Gluconate** : metabolism**?**, converted to glucose by entry into citric acid cycle

Balanced Crystalloid Solutions

By the way , why not directly adding HCO3 to solutions ?

- **Possible** , but **limited** by **2** factors:

1. First, [redacted]
2. Second, [redacted]



Fluid Pharmacology / Crystalloids

Balanced Crystalloid Solutions

- **Excretion of excess water & electrolyte** is **more rapid** than isotonic saline

(**due ↓plasma tonicity → ↓ADH →diuresis**)

- **Less SID ↓** than NaCl solutions → **do not cause acidosis**
- **HCO_3^-** concentration is **maintained or slightly ↑ed**



Fluid Pharmacology / Crystalloids



Balanced Crystalloid Solutions

Potential negative effects:

1. **Lactated** Ringer solutions
   - **racemic** (d- and l-) lactate, large doses of **d-lactate →encephalopathy & card. Toxicity** (?)
   - **hepatic metabolism** → should be avoided in severe liver failure

2. **Acetate**
   - Acet…
   - …ing effects manifest as
     nausea, vomiting, headaches & cardiovas instability →
     removal of acetate from dialysis fluids
   - turnover is limited in
     - **ESRD**
     - In the **presence of other substrates e.g. lactic acidosis** or proteolysis

3. **Gluconate**-containing fluids: much less is known

This area requires investigation at a cellular, organ, and whole organism level

Dextrose Solutions

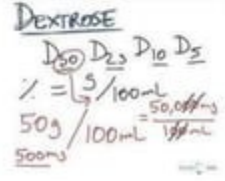


two main indications :

- 1. **As a source of free water**:
  - 5% D/W ≈ free water
  - In vitro osmolality ≈ plasma
  - No hemolysis
  - Hypotonic (dextrose is taken up into cells leaving free water)
  - Dilute plasma electrolytes and osmolality
  - Cautious use in postop. (possibility of SIADH) : leads to water retention, ↑risk for hyponatremia
  - Useful for maintenance particularly if combined with a low concentration of NaCl



- 2. **Source of metabolic substrate**:
  - **5%** dextrose : **inadequate calorie** for nutritional requirements
  - **50%** glucose : **4000 kCal/L**
  - **To prevent hypoglycemia in diabetics** : **10% dextrose at 75 mL/h**





REVIEW

Types of intravenous fluids

- Colloids
- Albumin
- Dextran
- HES

Fluid Pharmacology

Colloids

- **large molecules** of a **homogeneous non-crystalline** substance dispersed **in isotonic saline or balanced crystalloid**
- **Cannot be filtered**
- Products include
  1. **semisynthetic** colloids
  2. human **plasma derivatives**
- **Colloid molecules > 70 kDa** : No pass through EGM → **initial vol. of distribution is plasma** rather than **entire intravas**. vol.

Fluid Pharmacology

Colloids

- ↑ **COP** →
  - ***at low cap. hydrostatic pres*** :

    ↓ transcap. filtration → ↑↑ intravas. plasma vol.
  - ***at Nl or supranl cap. Pres*** ;

    ↑hydrostatic pressure → ↑ transcap. filtration

- **Colloid loss** from circulation :
  - by **filtration across impaired cap**. glycocalyx (inflammation or other stressors)
  - by **renal filtration** of smaller colloid molecules
  - by **removal** from circulation **by metabolism**

- Colloids have **variable** plasma **half-lives**

- Colloids **improving blood flow** by **hemodilution** →↓plasma viscosity & RBC aggreg.

Fluid Pharmacology



Colloids - Potential negative effects:

- **large doses** of colloids →
  undesired effects on the **immune, coagulation & renal sys.**→
  maximum dosages are recommended for most colloids **but**
  adverse effects may still occur

- **Use** of colloids, at least **in critical care**, deserves increasing **caution**

- **Differential effects of** isotonic saline vs balanced crystalloid as **carrier solutes** used in colloids **needs more study** & attention

Fluid Pharmacology / Colloids

Semisynthetic Colloids

Gelatins





- Derived from **bovine collagen**, with
  - succinylation : **Gelofusine (larger molecule)**
  - urea-linkage : **Haemaccel**
- **Excretion : Kidney**

- **Negative effects** ;
  - ***least* impact *on hemostasis*** of all semisynthetic colloids despite
    - ↓vWF, ↓factor VIII & ex vivo clot strength
  - ***highest*** incidence of ***anaphylactic and anaphylactoid* reactions** (<0.35%)
  - [redacted] **with citrated blood** products (same infusion set.)
  - Common in Europe - **not approved by FDA**

Hydroxyethyl Starches : derived from maize or potato



- **Size of starch** molecule is **responsible for** both **therapeutic** vol. effects & **adverse effects**
- **Elimination:**
  - **renal** excretion for **small** molecules.
- Starch-based colloids restricted or even completely suspended by the United States & Europe
- several
- Problems :
  - **Coagulopathy** : **In sepsis** →↑ risk of bleeding & transfusion (**unclear in periop.)**
  - **Accumulation** : **RES ,skin, liver, muscle, and gut** may persist for **several years**
  - **Renal dysfunction** : **oliguria,** ↑ **cr & AKI** in renal dis.
  - **Anaphylactoid Reactions** : **less than with other colloids** (<0.06%)

Fluid Pharmacology / Colloids

Human Plasma Derivatives



- Include
  - Albumin
  - plasma protein fractions
  - FFP
  - immunoglobulin solution
- Theoretic risk for **Creutzfeldt-Jakob dis.**



- **5% albumin** : near-physiologic COP of 20 mmHg ,
  used for vol. expansion
- Exogenous albumin **does not improve outcome in critical illness** with hypoalb.
- Concerns about **resuscitation with albumin** :
  - Mortality **in critical illness** : **no difference between albumin vs isotonic saline**
  - In trauma, esp. **TBI** : **albumin →↑mortality**

Crystalloid Versus Colloid



"Yours is medication, and mine is coffee. They're both vital to our well-being."

Clinical Fluid and Electrolyte Management

Before recommending practical **approaches** ;

It is important to **consider pathophysiologic processes affecting pt.**

- Pt. may
  - Enter with **abnormalities of intravas fluid vol & distribution**
  - **Subsequent trauma** (including surgery)→neurohumoral & inflammatory changes, (**stress response**) →significant impact on fluid & electrolyte
  - **Stress response**
    - **If appropriate** magnitude & duration: **beneficial** for recovery from trauma
    - **If exaggerated** or prolonged : **burden to pts** with limited physiologic reserves

Clinical Fluid and Electrolyte Management

Preoperative



Derangements of fluid & electrolyte :

- **Hepatic, renal & cardiac** dysfunction → **disordered Na+** distribution
- **ESRD** → preop. **timing of dialysis** is critical
- Chronic **diuretic Rx.** → **electrolyte depletion**
- **Hypertensive pts** → **volume-contracted** circulation→ prone to **intraop. Hypovol.**
- Preop. **fasting**
  - Cessation of **oral fluids only 2 hrs** before elective Sx.
  - **Bowel preparation** →**Wt. loss of 1.5 to 1.7 kg** (**water and K+**)

    (Rx. : restricting bowel prep + 1 to 2 L of crystalloid with K+)

Clinical Fluid and Electrolyte Management

Intraoperative



Many factors influence intraop **fluid balance**, such as:

- **Altered distribution** of intravas. vol
  - **vasodilation** (venous & arterial)
  - **negative inotropic** effect →↓ cardiac preload & afterload
  - **sympathetic blockade** by neuraxial blockade
  - **Blunting of autoregulatory** responses **within organ** beds
  - **Microcirculatory dysfunction** : anesthesia & inflammatory resp.→
    → impaired matching of O2 del. with tissue O2 req.

Clinical Fluid and Electrolyte Management

Intraoperative

- **Hemorrhage** (Vol & time course of blood loss)

- **Insensible losses**
  - ✓ opening of anatomic comp → evaporative fluid loss from mucosal surfaces
    (estimation ?? [redacted] during a major laparotomy)



- **Inflammation-related redistribution**
  - ✓ Major Sx. → inflammatory resp. → redistributes **fluid from intravas to extracell** comp.

- Renal output
  - ✓ ↑ADH
  - ✓ Positive-pressure vent (↓VR & CO)
  - ✓ Sympathetic activation
  - ✓ ↓ANP

As a result,
Intraop. urine output may be low
regardless of
the vol of IVF administered

Clinical Fluid and Electrolyte Management

Postoperative



Inflammation and Immune Response

- **Tissue injury leads to**
  - local vasodilation
  - ↑endothelial permeability
  - influx of leukocytes → proinflam. cytokines for 72 hrs

- **Systemic inflam.** →↑endothelial large pores & **degradation of EGM**

- **Hypervol.** →↑ANP → **degradation of EGM**

- **inflammation**-related endothelial dysf. →
  a capillary leak synd. → loss of water, elect. & proteins into interstitial space →
  edema in the lungs, bowel & connective tissue

- ↓ **plasma oncotic pressure** → **ongoing cap. fluid filtration** into extravas. space & **consequent hypovolemia**

Clinical Fluid and Electrolyte Management

Postoperative

Catabolic Metabolism

- **Response to tissue injury requires an ↑ energy** substrate delivery esp. to leukocytes involved in acute inflammatory & immune reaction

- **↑catecholamine & cortisol release →muscle** protein catab. , **hepatic** gluconeogenesis & acute phase protein production

Both ↑**basal metabolic** rate & **adeq. circulating vol. are required** to meet ↑ fuel needs

Clinical Fluid and Electrolyte Management

Postoperative

Regulation of Salt and Water Balance

- Intraop. ADH →postop. retention of water
- hypovol. & hypotension → ↑ADH & RAA system
- Postop hypercatabolic state →↑nitrogen →↓Na+ excretion

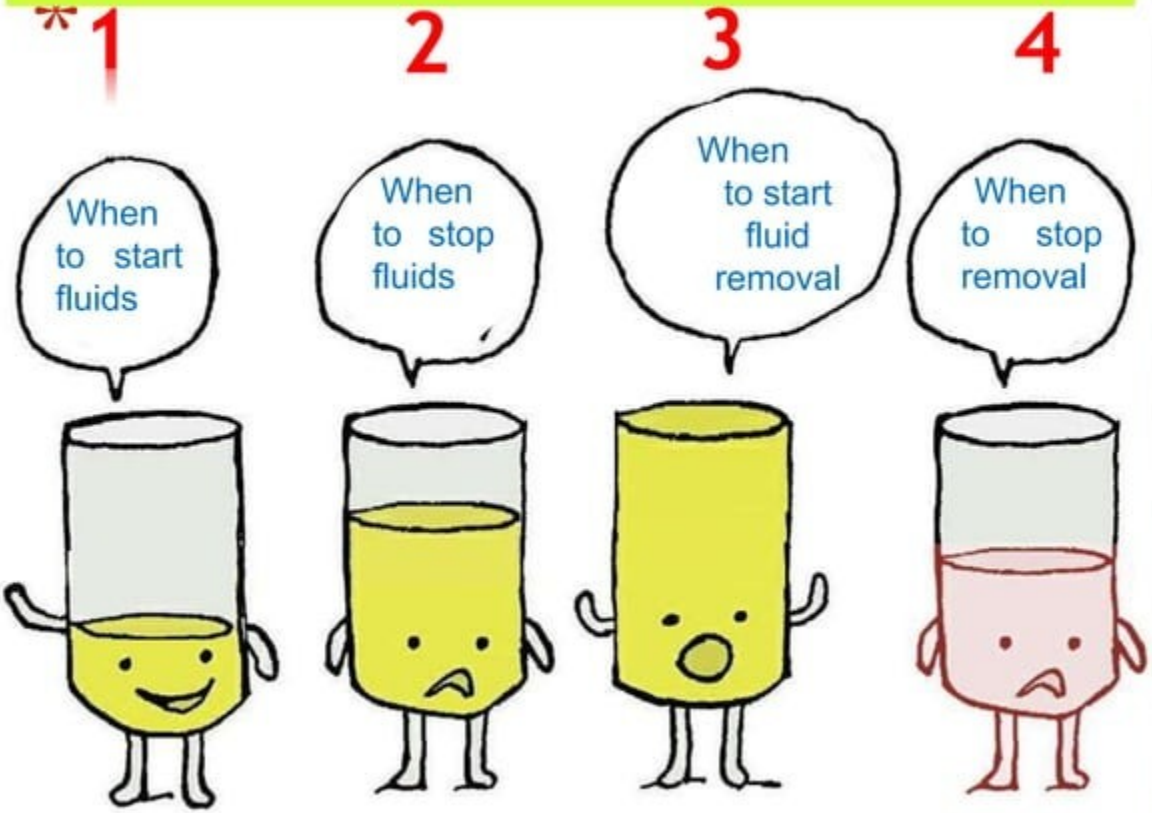
oliguria ,
postop. Fluid overload
Na fluctuation

Fluid ;

- **reaccumulation** into third spaces ; ascites or pleural effusions
- **sequestration** into bowel lumen
- **removal** through vomiting, NGT or stoma



PRACTICAL MANAGEMENT OF PERIOPERATIVE FLUID THERAPY



PRACTICAL MANAGEMENT OF PERIOPERATIVE FLUID THERAPY

- **At each stage in periop**. journey ; **how much** & **what type** of **IVF**
- Fluid & elect. requirements : **dynamic with great inter-individual variability**
- Different **fluid requirements** depends on:
  - ✓ **pt factors**, e.g. wt & comorbidity
  - ✓ **Sx. factors**, such as magnitude & site of Sx.
- How **fluid strategies affect post op.** events:
  - ✓ In **minor Sx.** → minor morbidity e.g. **PONV**
  - ✓ In **major Sx.** → morbidity, LOS & mortality

PRACTICAL MANAGEMENT OF PERIOPERATIVE FLUID THERAPY

Quantity of Fluid

- **2** main ways:

1. Estimating require. based upon
   pt wt , phase of sx. & nature of losses

1. Measurement of physiologic variables,
   so-called **goal-directed therapy**



Quantity of Fluid

1. *Targeting Overall Fluid Balance*

(My mnemonic : CDMLT)

TABLE 47.15 The 4-2-1 Estimation of Maintenance Water Requirements

Weight	Fluid Prescription
First 10 kg	4 mL/kg/h
Second 10 kg	2 mL/kg/h
All subsequent kilograms	1 mL/kg/h

Example: A 25-kg patient would require (4 × 10) + (2 × 10) + (1 × 5) = 65 mL/h "maintenance" water.

Data from Holliday MA, Segar WE. The maintenance need for water in parenteral fluid therapy. *Pediatrics*. 1957;19:823.

- Traditional approaches ;
  - fasting (e.g., "4-2-1" calculation)
  - loss when body cavities are open
  - bleeding → crystalloid to blood loss ≈ 3:1 ratio (crystalloid extravas. mov.)

much of the physiologic basis of this management has been questioned recently



Quantity of Fluid

1. *Targeting Overall Fluid Balance*

When **fluid** is given **by a ml/kg** protocol **& clinical assessment**
rather than
to target defined physiologic endpoints

3500 to 5000 mL of crystalloid solution

↑ **postop. Morbidity**
in contrast to
administration of lower fluid volumes

↑ **wt. gain, cardiopulmonary dysfunction,**
impaired wound healing , delayed GI function & ↑ hospital LOS

PRACTICAL MANAGEMENT OF PERIOPERATIVE FLUID THERAPY

Quantity of Fluid

Individualization of fluid Rx.

where objective variables are measured & targeted with fluid therapy

Practical Management of Periop. FLUID Rx.

Quantity of Fluid

2. Goal-Directed Therapy

measuring physiologic variables of **C.O.** or **O2 delivery** &
administering fluids **& possibly inotropes, vasopressors, vasodilator & RBCs**
to improved tissue perfusion & clinical outcome

A continuous dynamic process
that
targets defined physiologic endpoints
rather than
giving fluids without objective assessments of fluid status

PRACTICAL MANAGEMENT OF PERIOPERATIVE FLUID THERAPY

Quantity of Fluid



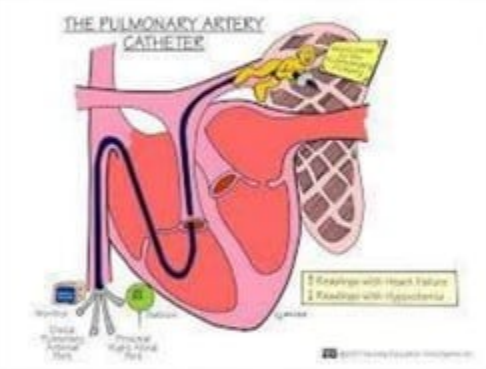
Various tools are available to measure the physiologic targets of GDT

Quantity of Fluid
2. Goal-Directed Therapy

A. Pulmonary artery catheter

Gold standard hemodynamic monitor,

- values for
  - **Lt & Rt heart filling pressures**
  - **Scvo2 & Svo2**
  - **C.O.**
  - **DO2 & VO2**
- **access to central** circulation



- its use is **declining** because of
  I. Catheter-associated **morbidity**
  II. ↓ **expertise** in insertion & data interpretation
  III. Availability of **less invasive tools**

Quantity of Fluid
2. Goal-Directed Therapy

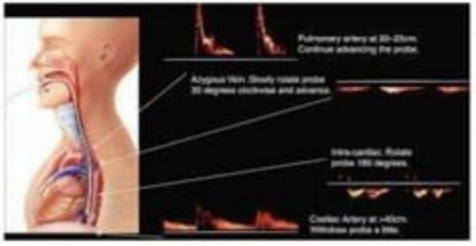


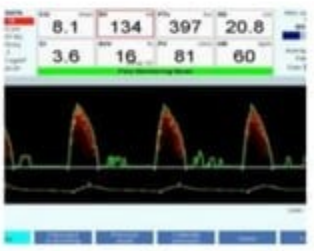
B . Esophageal Doppler monitor (EDM)

Transesophageal **ultrasound** →

- descending **orta blood velocity** & aortic cross-sectional → **SV**
- peak velocity →**ventricular contractility** & corrected flow time (FTc)
- **SVR** calculated by inputting CVP & MAP
- **SVV** is also measured by latest models







Quantity of Fluid

2. Goal-Directed Therapy

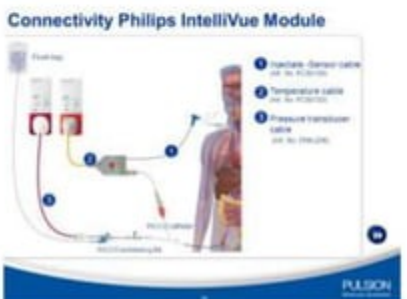
C . Arterial pressure and waveform analysis

1. **invasive arterial BP**
2. continuous **NIBP** from a **finger cuff** (plethysmograph)



- **Calibration**
  - lithium dilution (**LiDCO**)
  - thermodilution (**PiCCO**)

- **SVV, a predictor of fluid resp.** (syst. pressure variation with IPPV)

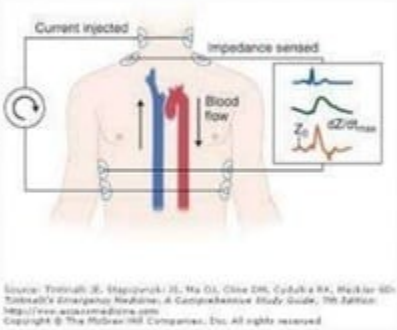


Quantity of Fluid

2. Goal-Directed Therapy

D . Thoracic bioimpedance

- relatively underexplored in periop. interventional trials

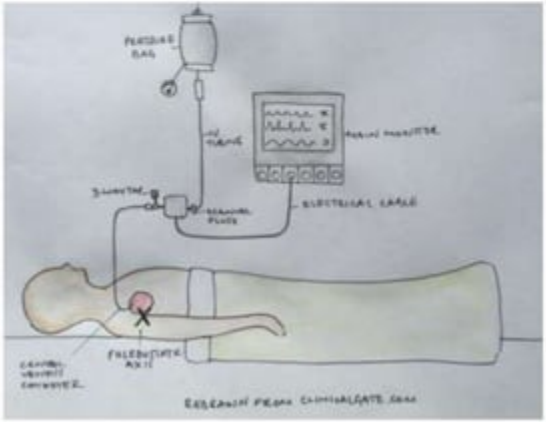


Quantity of Fluid

2. Goal-Directed Therapy

E . CVP

CVP readings



Quantity of Fluid
2. Goal-Directed Therapy

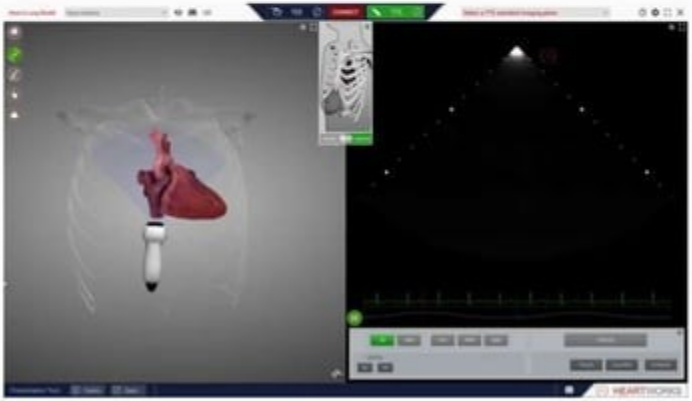
F . Echocardiography

Benefits:

- Guiding fluid Rx.
- Estimation of card. performance & filling

Restrictions:

- Operator expertise
- TEE in intraop. setting



Quantity of Fluid
2. Goal-Directed Therapy

G . Lactate

A **reduction in elevated blood lactate** is used clinically as a marker of successful resuscitation

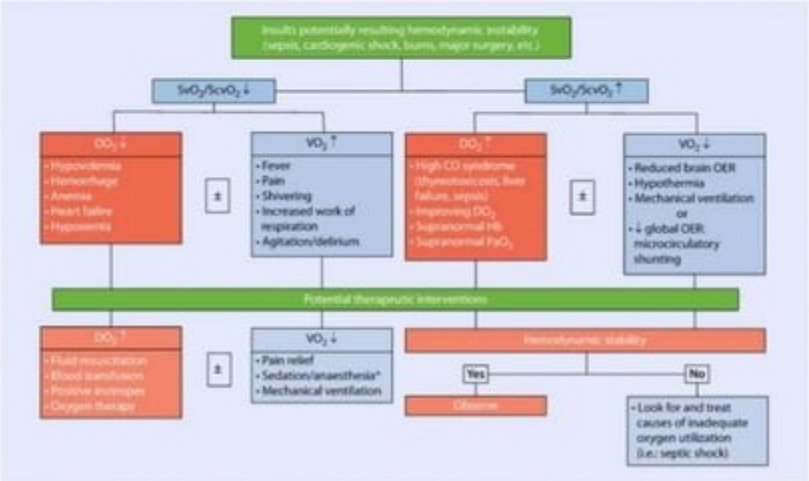


Quantity of Fluid
2. Goal-Directed Therapy

H. O2 extraction & (SvO2) or (ScvO2)

- Inadequate tissue **O2 delivery** _____ increased **O2 extraction**

- Low ScvO2 is associated with **poor outcomes** after high-risk surgery **???**



Quantity of Fluid
2. Goal-Directed Therapy

Anesthesiology 2009; 110:453–5
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Goal-directed Perioperative Fluid Management

Why, When, and How?



GDT is associated with :

- ↓Postop morbidity
- ↓Hospital LOS
- ↓Postop. renal dys.
- ↓Postop. Resp. failure
- ↓Postop. wound infection
- ↓Hospital or 28-day mortality

Quantity of Fluid
Goal-Directed Therapy

A typical approach to GDT :

Rapidly administer **250 mL** boluses of **colloid or crystalloid**

Aiming to ↑ **SV by 10%** or more each time

Continued **until** there is **no further rise in SV**

Various trails :

1. **Intra- & postop**. application **???**
2. **Protocolized fluid + inotrope ???**



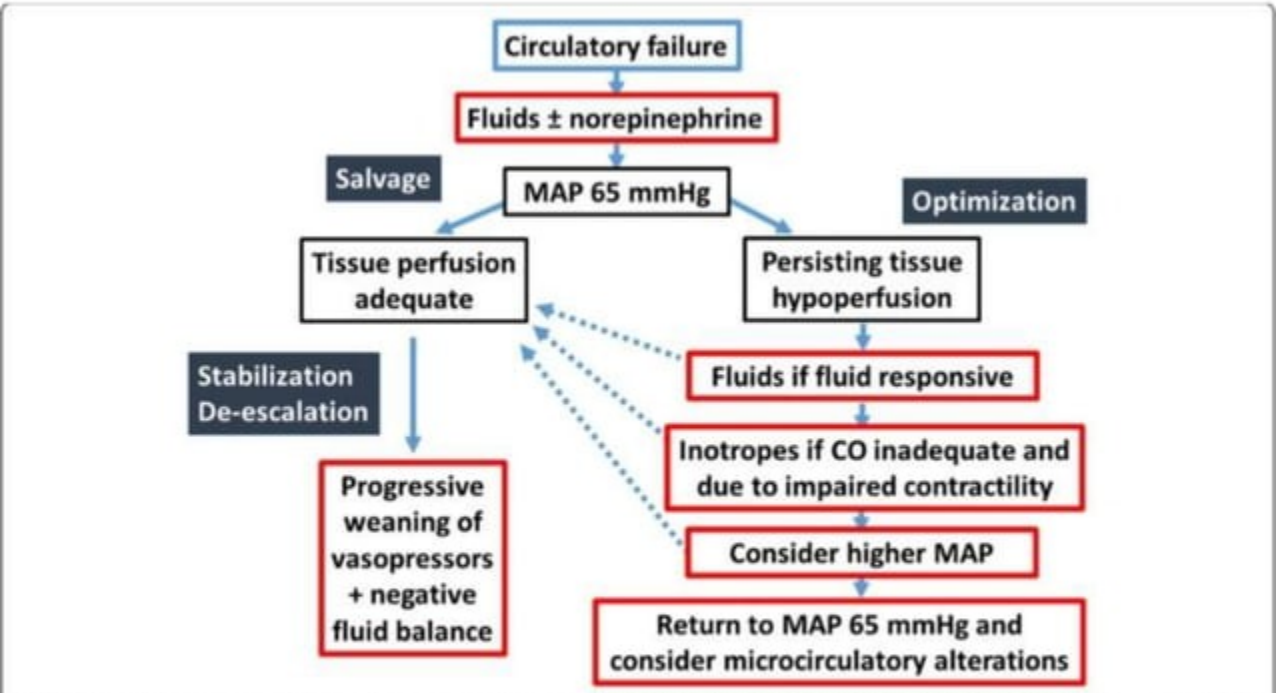


Fig. 2 Suggested algorithm for tissue perfusion optimization. According to the phase of therapy (salvage/optimization/stabilization/de-escalation), different targets of resuscitation should be selected. Interventions should be progressively implemented, evaluating their effects and stopping it when ineffective. Once the patient is stabilized, weaning vasoactive agents and achieving a negative fluid balance should be considered

Clinical relevance



Appropriate Fluid Selection

Crystalloids or Colloids *for Intravas. Plasma Vol Expansion*

- Crystalloids : most rational choice for
  - **evaporative losses**
  - **maintenance** fluid
  - **expansion of *entire* ECFV**

The **choice of crystalloid or colloid** for plasma vol. replacement in periop. phase is **not clear**



- **What about GDT , couldn't it help us** :
  1. GDT compared **guided** vs **non-guided** fluid Rx
  2. Most GDTs used colloid for intravas vol. expansion → **crystalloid-based GDT merits further investigation**

Appropriate Fluid Selection



Crystalloids* or *Colloids *for Intravas. Plasma Vol Expansion*

- *Crystalloids*

- **More crystalloid** (40-50%) needed **for the same vol. effect**

- More **extravas**. Vol. expansion occurs →tissue edema

- More ↑**GI mucosal edema** → delayed postop. GI function & **bacterial translocation**

Appropriate Fluid Selection

Crystalloids or Colloids *for Intravas. Plasma Vol Expansion*

➢ *Colloids*

- **lack of improvement in all-cause mortality** in unselected critical care pts
- In sepsis, **starch-based colloids**→ ↑RRT , blood TQ & ↑adverse events

(surgical population ≠ critical care pts)

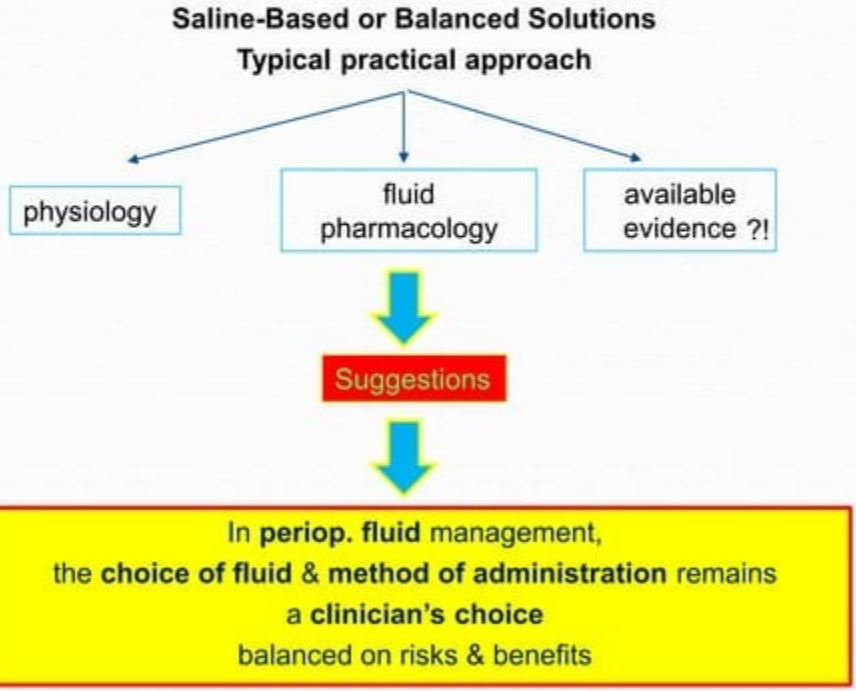


What about *saline* vs *balanced*?





Appropriate Fluid Selection



Appropriate Fluid Selection

Saline-Based or Balanced Solutions

Typical practical approach



- Overall in moderate-to-major Sx.:
  - **Maintenance fluid** ; at **a low fixed rate**
  - **Replacement of losses/resuscitation : separately**
  - **Postop. maintenance** fluids on a **cc/kg** basis
  - **Intraop.** based on **physiologic variables**

1. **Fluid status changes** constantly → **frequently reassessed**
2. **Approach** should be **adapted to the pt & surgical** factors

Appropriate Fluid Selection

Ongoing IVF therapy:

- **Check Electrolytes** at least , daily

- **Fluid requirements** divided into **3 categories**
  1. **Pure" maintenance requirements**
  2. **Replacement of ongoing losses**
  3. **New requirements (resuscitation)**

Appropriate Fluid Selection



"Pure" ***maintenance*** *requirements*

Should be **salt-poor** & contain a **modest free water**

- **24 hr. maintenance IVF** :
  - **1500 to 2500** mL *or* **1-1.2 mL/kg/h** based on **ideal body wt**
  - **50 to 100 mEq Na+**
  - **40 to 80 mEq K+**

- **Part of this** maintenance IVF should comprise
  - **hypotonic fluids** such as **5% dextrose** or
  - **0.18% saline with 4% dextrose**

Appropriate Fluid Selection



***Replacement** of* ongoing losses

- Requires **frequent reassessment**
  - ✓ measured **amounts lost**
  - ✓ assessment of **intravas vol status**
  - ✓ adequacy of **organ perfusion (GDT)**

- **GI losses** (vomiting, nasogastric aspirates, stoma) → **equal vol** of **isotonic saline** or **balanced crystalloid with K+**

- **Third space loss →mixture of colloid & crystalloid**

- **blood loss → colloid, blood, or blood products**

Appropriate Fluid Selection

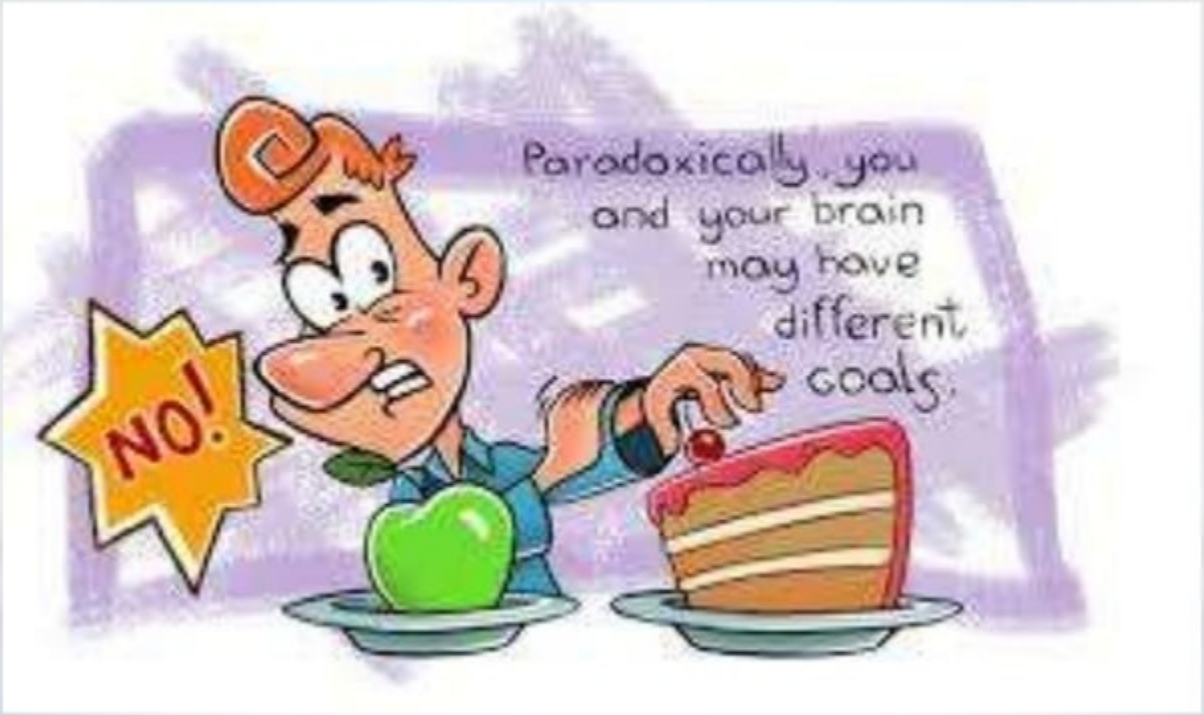


New requirements (resuscitation)

Postop. complications such as

- hemorrhage (absolute hypovolemia)
- acute sepsis (relative or absolute hypovolemia)

Wrap it up


Paradoxically, you and your brain may have different goals.
NO!

50 little bags of chips= 1 liter 0.9% NaCl



- Clinical decision about fluid Rx. :
  1- which fluid to use
  2- How much fluid to give

- Despite "mega-trials" ; key questions remain unresolved

Journal of Thoracic Disease, Vol 11, Suppl 15 September 2019

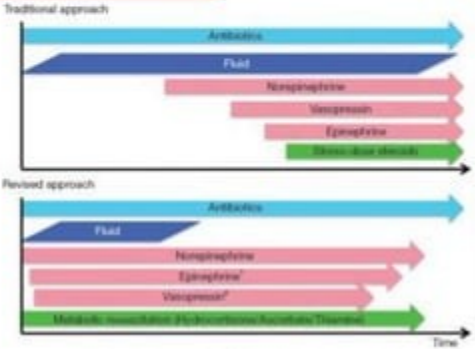
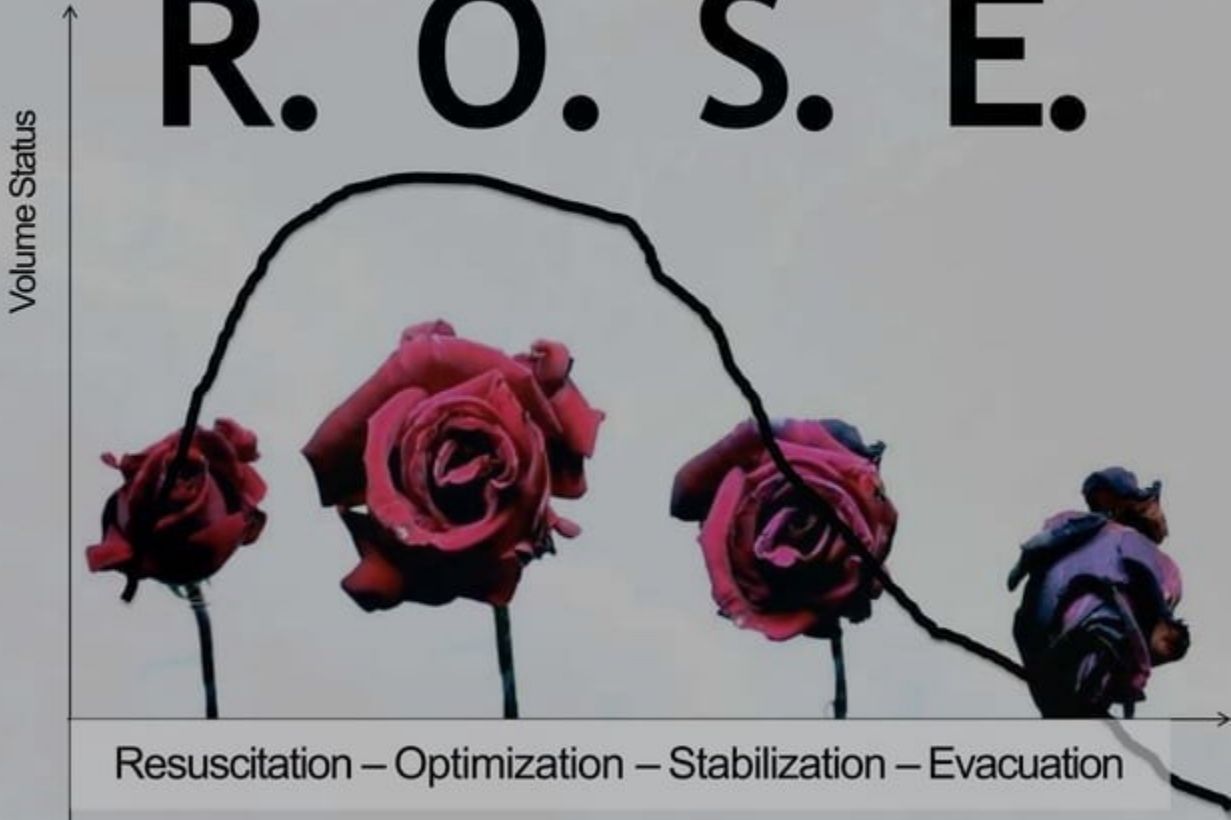


Figure 1 Paradigm change in the management of sepsis and septic shock. Reproduced with permission from Society of Critical Care Medicine and Wolters Kluwer Health, Inc. (25).

R. O. S. E.


Volume Status
Resuscitation – Optimization – Stabilization – Evacuation

Start IV fluid



Stop IV fluid



Start removal



Stop removal




Thank you