Principles of fluid and electrolyte balance in surgical patients

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Objectives:

- Identify types of intravenous fluids
- Revision of fluid compartments **(physiology part) (fluid & substance)**
- Prescribing fluids
- Electrolytes abnormalities
- Acid-base balance

Lecture reference

- Principles & practice of surgery book
- 5th edition
- By O. james Garden…….

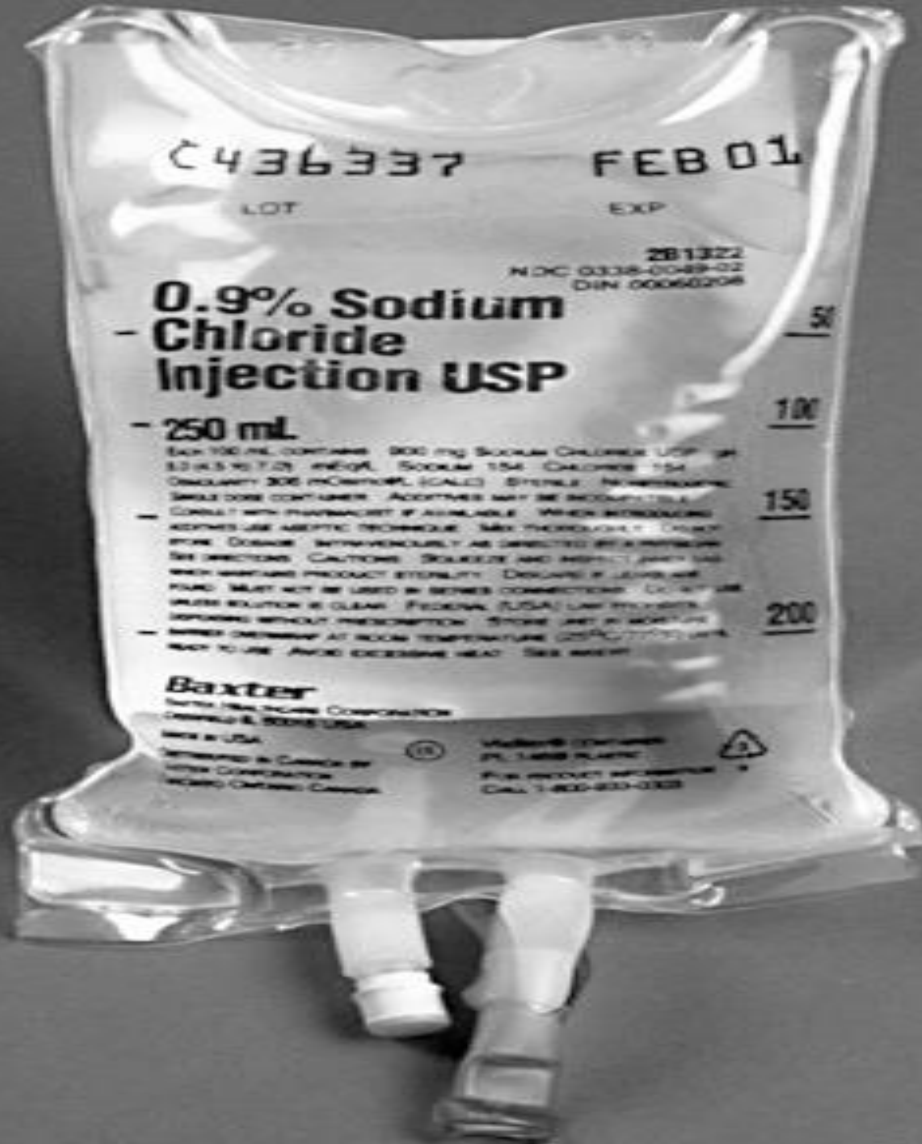
Why it is important?????

- Very basic requirements
- Daily basic requirements
- You will be asked to do it as junior staff
- **To maintain patient life**

Theory part

Definition

- **Intravenous** (**IV**) **fluids** are infused to maintain **fluid** balance, replace **fluid** losses, and treat electrolyte imbalances.
- They are commonly available in volumes ranging from 25 mL to 1,000 mL and are
- dispensed in either plastic bags or glass bottles.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FEB01
LOT
EXP
2B1322
0.9% Sodium Chloride Injection USP
250 mL
100
150
200
Baxter

Intravenous fluids

- **IV fluid** is the giving of **fluid and substances** directly into a vein.
- Human Body has fluid and substances

Substances that may be infused intravenously

- **volume expanders (crystalloids and colloids)**
- blood-based products (whole blood, fresh frozen plasma, cryoprecipitate)
- blood substitutes,
- medications.

First part is fluid

Iv fluids

What type of IV fluid do you know?????

- Crystalloids
- Colloids

Iv Fluids

- **Colloid solutions**

  Containing **water** and **large proteins** and molecules

  tend to stay within the vascular space

- **Crystalloid solutions**

  containing **water** and **electrolytes.**

Colloid solutions

- IV fluids containing large proteins and molecules
- **tend to stay within the vascular space and increase intravascular pressure**
- very expensive
- Examples: Dextran, hetastarch, albumin…

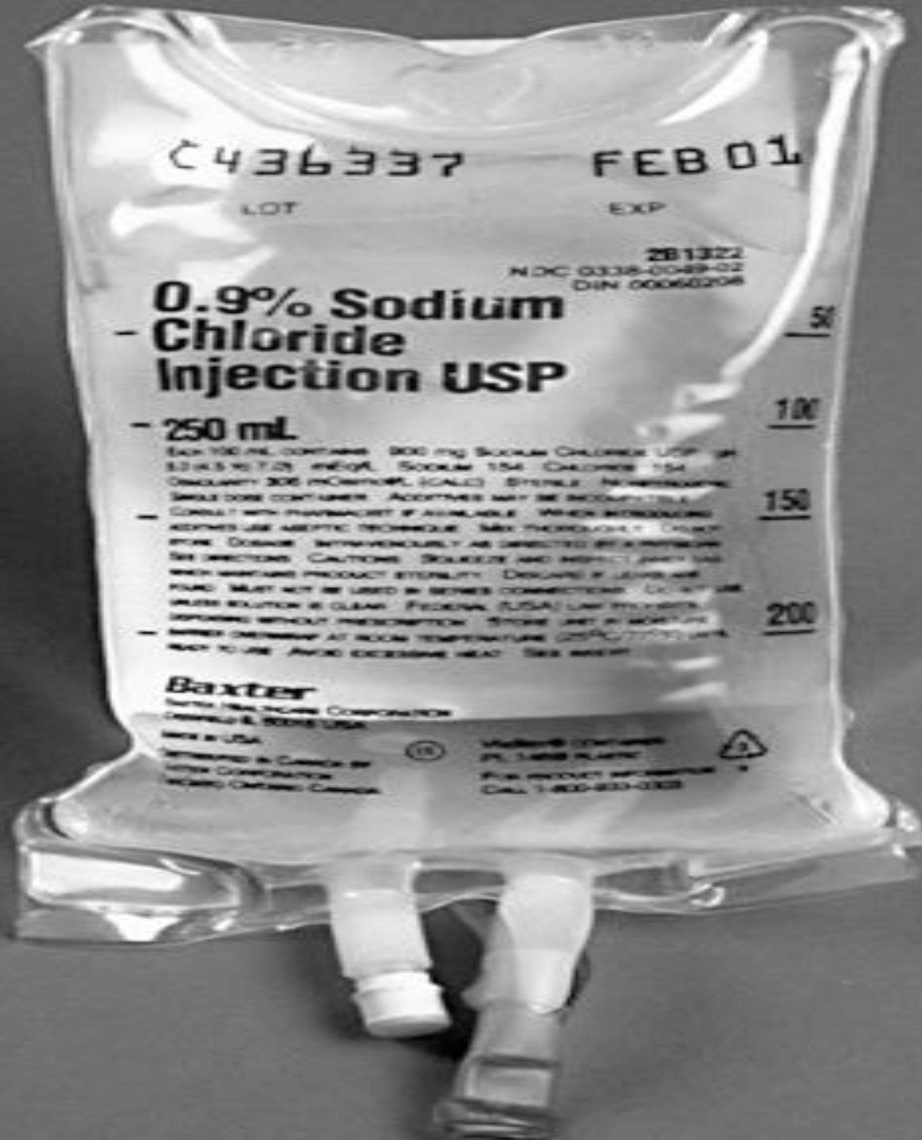
Crystalloid solutions

- Contain electrolytes (e.g.,sodium, potassium, calcium, chloride)
- Lack the large proteins and molecules
- Come in many preparations and volum
- Classified according to their “tonicity:
- ” 0.9% NaCl (normal saline), Lactated Ringer's solution **isotonic**,
- 2.5% dextrose **hypotonic**
- D5 NaCl **hypertonic**

Calculation of osmolality

- Difficult: measure & add all active osmoles
- Easy = [sodium x 2] + urea + glucose
- Normal = 280 - 290 mosm / kg

Type of fluid*	Sodium mmol/L	Potassium mmol/L	Chloride mmol/L	Osmolority mmom/L	Weight average mol wtkd	Plasma volume expansion duration hrs+
plasma	**136 - 145**	**3.5 – 5.0**	**98 -105**	**280 - 300**	-	-
5% Dextrose	0	0	0	278	-	-
Dextrose 0.18% saline	30	0	30	283		
0.9% “normal” saline	154	0	154	308	-	0.2
0.45%”half normal” saline	77	0	77	154	-	
Ringer’s lactate	130	4	109	273	-	0.2
Hartmann’s	131	5	111	275	-	0.2
Gelatine 4%	145	0	145	290	30,000	1-2
5% albumin	150	0	150	300	68,000	2-4
20% albumin	-	-	-	-	68,000	2-4
Hes 6% 130/0.4	154	0	154	308	130,000	4-8
Hes 10% 200/0.5	154	0	154	308	200,000	6-12
Hes 6% 450/0.6	154	0	154	308	450,000	24-36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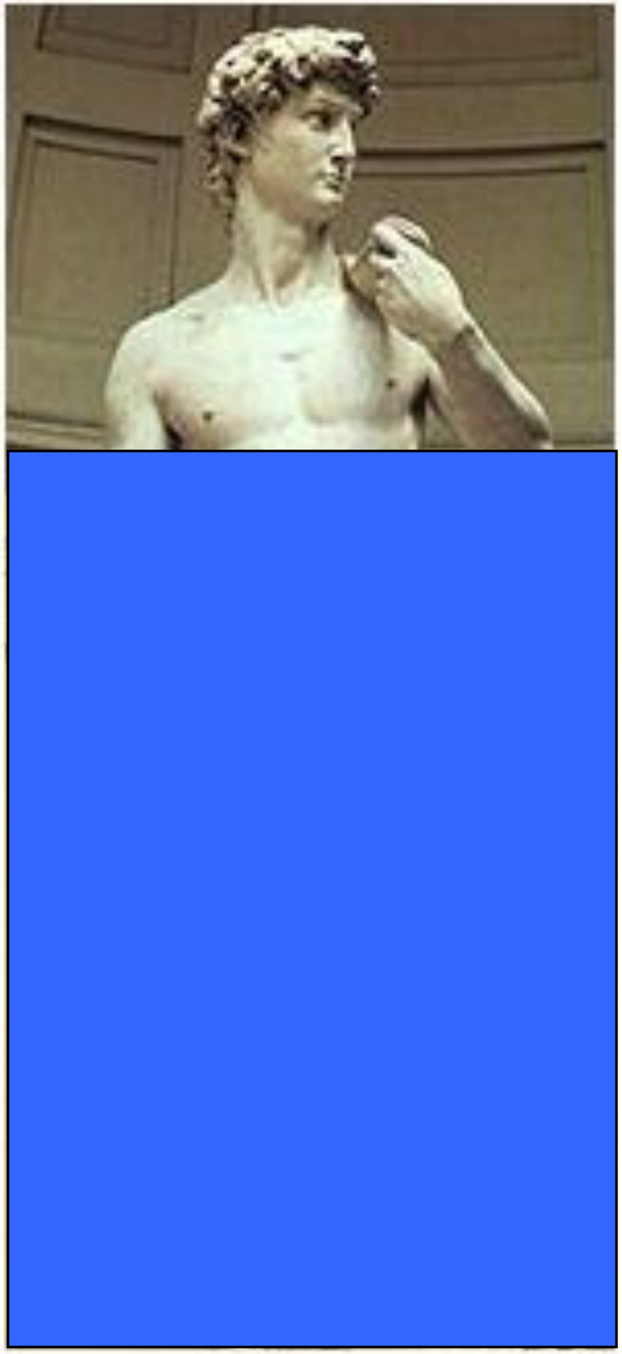
Normal saline fluid (NS 0.9%)

- (NS) — is the commonly-used term for a solution of 0.90% w/v of NaCl, about 300 mOsm/L or 9.0 g per liter
- Na is154 and only CL 154
- No K, NO others

Hartmann's fluid

- One litre of Hartmann's solution contains:
- 131 mEq of sodium ion = 131 mmol/L.
- 111 mEq of chloride ion = 111 mmol/L.
- 29 mEq of lactate = 29 mmol/L.
- 5 mEq of potassium ion = 5 mmol/L.
- 4 mEq of calcium ion = 2 mmol/L .

- Revision of fluid compartments **(physiology part) (fluid & substance)**



We are approximately two-thirds water

General information

- Total body water is 60% of body weight
- Influenced by age,sex and lean body mass
- Older age and female sex is less precent
- To calculate TBW needed:

  Male sex TBW= BW × 0.6

  Female sex TBW= BW × 0.5

Body fluid compartments:

- **Intracellular volume**

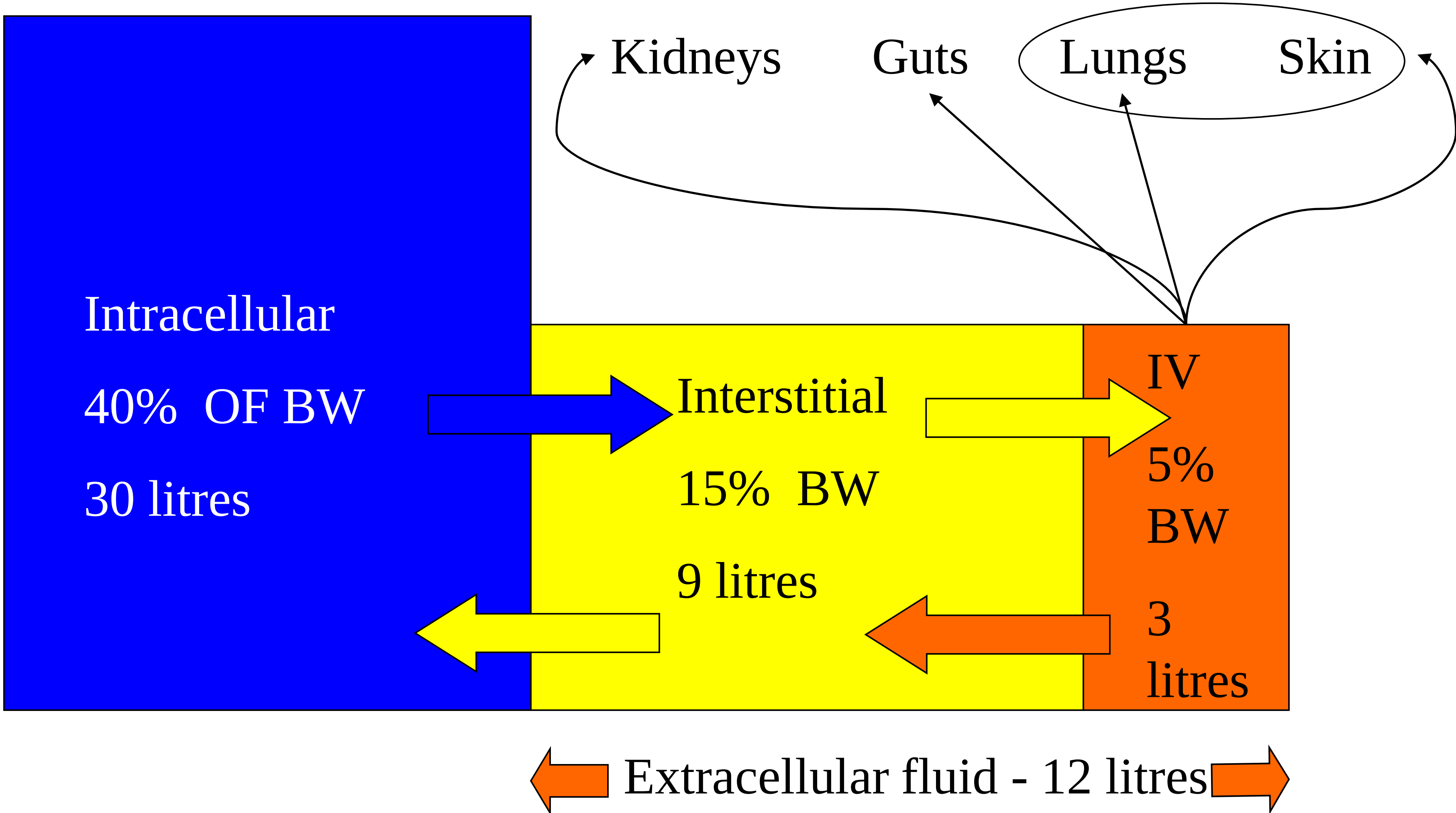
  (40%) rich in water

- **Extra cellular volume**

  (20%) rich in water

  15% constitute interstitial space and
  5% the intravascular space.

Fluid shifts / intakes



Second part is electrolytes

Body electrolytes compartments:

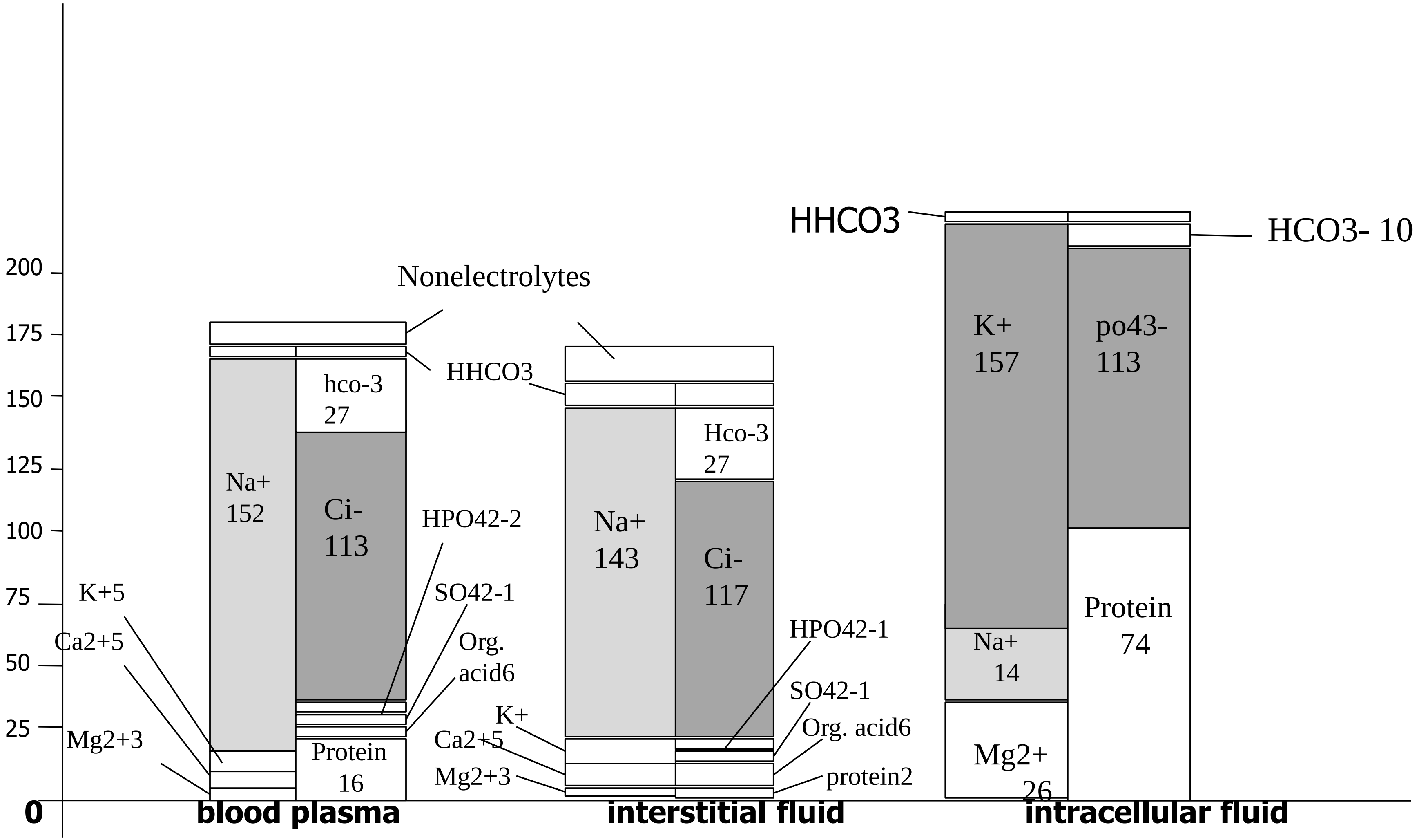
- **Intracellular volume**

  K+, Mg+, **and Phosphate (HPO_4^-)**

- **Extra cellular volume**

  Na+, **Cl-**, Ca++, and Albumin

Normal values of electrolytes



EXAMPLE 1(How much fluid in your body ?)

- Fluid Compartments
- 70 kg male: (70x 0.6)
- TBW= 42 L
- Intracellular volume = .66 x 42 = 28 L
- Extracellular volume = .34 x 42 = 14 L
- Interstitial volume = .66 x 14 = 9 L
- Intravascular volume = .34 x 14 = 5 L

Daily requirements of fluid and electrolytes

Fluid Requirements

- **Normal adult requires approximately 35cc/kg/d**
- **“4,2,1” Rule l hr**

  First 10 kg= 4cc/kg/hr

  Second 10 kg= 2cc/kg/hr

  1cc/kg/hr thereafter

Normal daily losses and requirements for fluids and electrolytes

	Volume (ml)	Na+ (mmol)	K+ (mmol)
Urine	2000	80	60
Insensible losses	700	--	--
(skin and respiratory			
tract)	300	--	10
Faeces			
Minus endogenous	300	--	--
Water	2700	80	70
Total			

Fluid shifts in disease

- Fluid loss:
  - GI: diarrhoea, vomiting, etc.
  - renal: diuresis
  - vascular: haemorrhage
  - skin: burns
- Fluid gain:
  - Iatrogenic:
  - Heart / liver / kidney failure:

WHAT IS THE RATE ?

- **In adults remember IVF rate = wt (kg) + 40.**

(70 + 40 = 110cc/hr)

“4,2,1” Rule / hr

- Assumes no significant renal or cardiac disease and NPO.
- This is the maintenance IVF rate, it must be adjusted for any dehydration or ongoing fluid loss.

Sodium requirement

- Na: 1-3 meq/kg/day

- FOR EXAMPLE:
- 70 kg male requires 70-210 meq NaCl in 2600 cc fluid per day.

- WHICH FLUID IS THE BEST
- 0.45% saline contains 77 meq NaCl per liter.
- 2.6 x 77 = 200 meq
- Thus, 0.45% saline is usually used as MIVF assuming no other volume or electrolyte issues.

Potassium requirment

- Potassium: 1 meq/kg/day
- K can be added to IV fluids. Remember this increases osm load.
- 20 meq/L is a common IVF additive.
- This will supply basal needs in most pts who are NPO.
- If significantly hypokalemia, order separate K supplementation.
- Oral potassium supplementation is always preferred when feasible.
- **Should not be administered at rate greater than 10-20 mmol/hr**

Third part is medicine

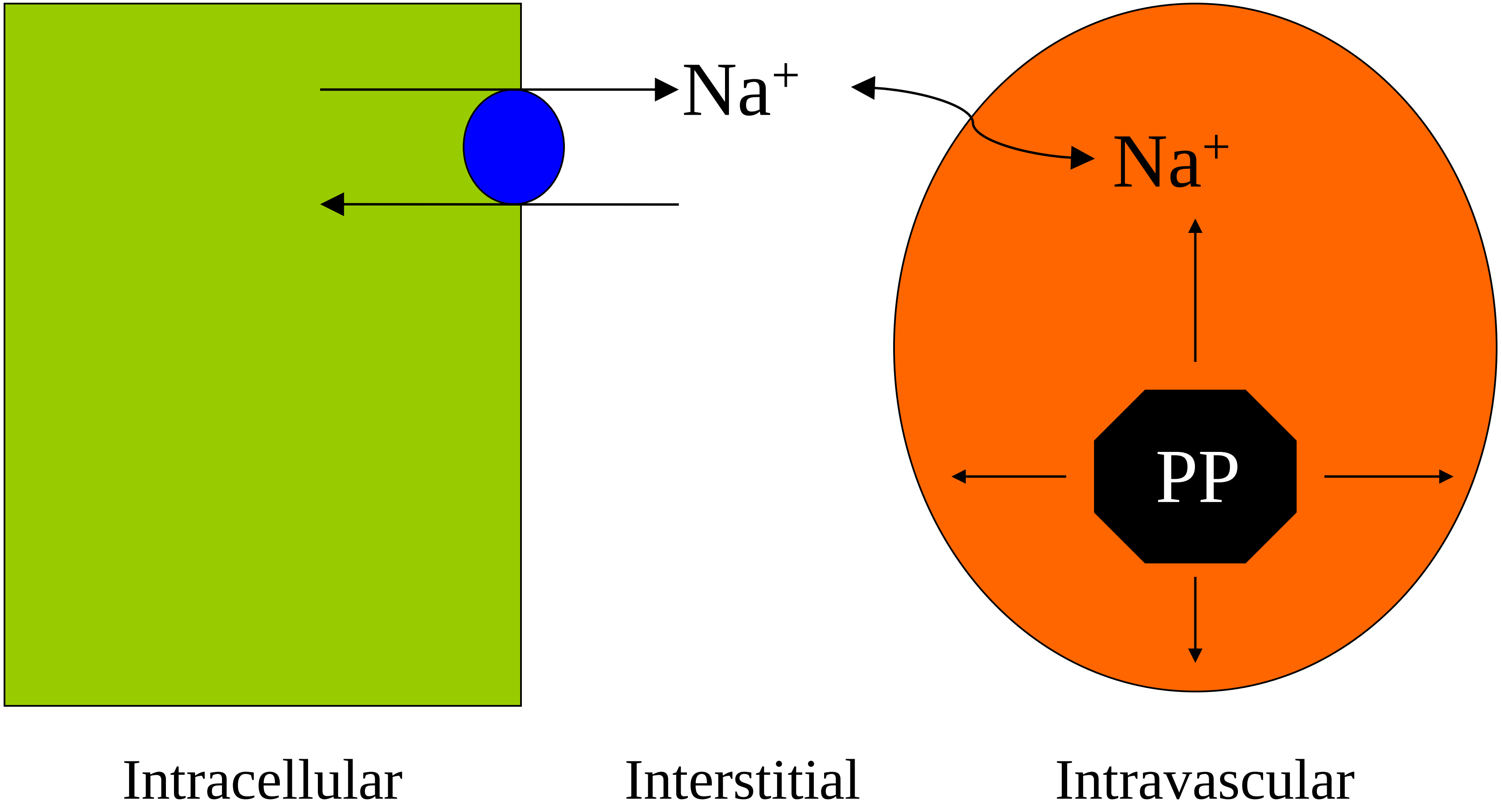
CASE FOR PRACTICE

- **FLUID 35/KG/DAY,**

  Na: 1-3 meq/kg/day.,

  K: 1 meq/kg/day
- 70 kg male requires 2450 cc fluid per day, 70-210 meq Na
- 0.45% saline contains 77 meq NaCl per liter.
- 2.6 x 77 = 200 meq
- Thus, 0.45% saline is usually used as MIVF assuming no other volume or electrolyte issues.

Osmotic / oncotic pressure
Gibbs – Donnan Equilibrium



Terminologies:

- **A solvent** is the liquid where particles dissolves in (e.g. Water) that can be measured in liters and milliliters
- **Solutes** are the dissolving particles
- **A molecule** is the smallest unit with chemical identity (e.g. Water consist of one oxygen and two hydrogen atoms = water molecule)
- **Ions** are dissociated molecule into parts that have electrical charges (e.g. NaCl dissociates into Na+ and Cl-)
- **Cations** are positively charged ions (e.g. Na+) due to loss of an electron (e-) and **anions** are negatively charged ions (e.g. Cl-) due to gain of an electrone (e-)
- **Electrolytes** are interacting cations and anions (e.g. H+ + Cl- = HCL [hydrochloric acid])
- **A univalent** ion has one electrical charge (e.g. Na+). A divalent ion has two electrical charges (e.g. Ca++)

- **Molecular weight** is the sum of atomic weights of different parts of a molecule (e.g. H+ [2 atoms] + O_2 [16 atoms] = H_2O [18 atoms])
- **A mole** is a measuring unit of the weight of each substance` in grams (e.g. 1 mole of Na+ = 23 grams, 1 mole of Cl- = 35 grams, 1 mole of NaCl = 58 grams). It can be expressed in moles/L, millimoles x 10^{-3}/L, micromoles x 10^{-6}/L of the solvent.
- **Equivalence** refers to the ionic weight of an electrolyte to the number of charges it carries (e.g. 1 mole of Na+ = 1 Equivalent, whereas 1 mole of Ca++ = 2 Equivalents). Like moles, equivalence can also be expressed in milliequivalent/L and microequivalent/L of the solvent.
- **Osmosis** is the movement of a solution (e.g. water) through a semi permeable membrane from the lower concentration to the higher concentration.
- **Osmole/L or milliosmole/L** is a measuring unit for the dissolution of a solute in a solvent
- **Osmotic coefficient** means the degree of dissolution of solutes (molecules) in a solvent (solution). For example the osmotic coefficient of NaCl is 0.9 means that if 10 molecules of NaCl are dissolved in water, 9 molecules will dissolve and 1 molecule will not dissolve.

- **Osmolarity** is the dissolution of a solute in plasma measured in liters, whereas **Osmolality** is the dissolution of a solute in whole blood measured in kilograms. Therefore, **Osmolality** is more accurate term because dissolution of a solute in plasma is less inclusive when compared to whole blood that contains plasma (90%) and Proteins (10%).

- **Gibbs – Donnan Equilibrium** refers to movement of chargeable particles through a semi permeable membrane against its natural location to achieve equal concentrations on either side of the semi permeable membrane. For example, movement of Cl- from extra cellular space (natural location) to intracellular space (unusual location) in case of hyperchloremic metabolic acidosis because negatively charged proteins (natural location in intravascular space) are large molecules that cannot cross the semi permeable membrane for this equilibrium.

- **Tonicity** of a solution means effective osmolality in relation to plasma (=285 milliosmol/L). Therefore, isotonic solutions [e.g. 0.9% saline solution] have almost equal tonicity of the plasma, hypotonic solutions [e.g. 0.45% saline solution] have < tonicity than plasma, and hypertonic [e.g. 3% saline solution] solutions have > tonicity than plasma.

Abnormal

Hypokalemia:

- Occurs when serum K+<3 mEq/L.
- **THE MOST COMMON SURGICAL ABNORMALITY**
- **Should not be administered at rate greater than 10-20 mmol/hr**

Causes of hypokalaemia

Reduced/inadequate intake

Gastrointestinal tract losses

- Vomiting
- Gastric aspiration/drainage
- Fistulae
- Diarrhoea
- Ileus
- Intestinal obstruction
- Potassium-secreting villous adenomas

Urinary losses

- Metabolic alkalosis
- Hyperaldosteronism
- Diuretic use
- Renal tubular disorders(e.g. bartter's syndrome, renal tubular acidosis, amphotericin-induced tubular damage)

Treatment of hypokalemia

- Treatment involves KCl i.v. infusion or orally.

Hyperkalemia:

- Diagnosis is established by ↑ serum K+>6 meq/L and ECG changes.
- Causes include increase K+ infusion in IVF, tissue injury, metabolic acidosis, renal failure, blood transfusion, and hemodialysis.
- Arrythmia is the presentation

Causes of hyperkalaemia

- Haemolysis
- Rhabdomyolysis
- Massive tissue damage
- Acidosis……..ARF

Management of high K

- Diagnosis is established by ↑ serum K+>6 meq/L and ECG changes.

- Treatment includes 1 ampule of D50% + 10 IU Insulin intravenously over 15 minutes, calcium exalate enemas, Lasix 20-40 mg i.v., and dialysis if needed.

Sodium Deficit (Hyponatremia):

- Causes are hyperglycemia, excessive IV sodium-free fluid administration

(Corrected Na= BS mg/dl x 0.016 + P (Na))

can be **volum over load, normo, low**

- Hyponatremia with volum overload usually indicates impaired renal ability to excrete sodium

Treatment of hypo Na

- Administering the calculated sodium needs in isotonic solution
- In severe hyponatremia (Na less than 120meq/l): hypertonic sodium solution
- Rapid correction may cause permanent brain damage duo to the osmotic **demyelination syndrom**
- **Serum Na sholud be increased at a rate not exceed 10-12meq/L/h**.

Sodium Excess (Hypernatremia):

- Diagnosis is established when serum sodium > 145mEq/L.
- this is primarily caused by high sodium infusion (e.g. 0.9% or 3% NaCl saline solutions).
- Another but rare cause is **hyperaldosteronism**.(What is function?)
- Patients with CHF, Cirrhosis, and nephrotic syndrome are prone to this complication
- Symptoms and sign of are similar to water excess.

Causes hypernatreamia

Reduced intake

- Fasting
- Nausea and vomiting
- Ileus
- Reduced conscious level

Increased loss

- Sweating (pyrexia, hot environment)
- Respiratory tract loss (increased ventilation, administration of dry gases)
- Burns

Inappropriate urinary water loss

- Diabetes insipidus (pituitary or nephrogenic)
- Diabetes mellitus
- Excessive sodium load (hypertonic fluids, parenteral nutrition)

Management of HN

- Diagnosis is established when serum sodium > 145mEq/L.
- Treatment include water intake and ↓ sodium infusion in IVF (e.g. 0.45% NaCl or D5%Water).

Water Excess:

- caused by **inappropriate use of hypotonic solutions** (e.g. D5%Water) leading to hypo-osmolar hyponatremia, and **Syndrome of inappropriate anti-diuretic hormone secretion (SIADH)**
- Look for SIADH causes :malignant tumors, CNS diseases, pulmonary disorders, medications, and severe stress.

The role of ADH:

- ADH = urinary concentration
- ADH = secreted in response to ⇑ osmo;
  = secreted in response to ⇓ vol;
- ADH acts on DCT / CD to reabsorb water
- Acts via V2 receptors & aquaporin 2
- Acts only on WATER

Symptoms of EW

- Symptoms of water excess develop slowly and if not recognized and treated promptly, they become evident by **convulsions and coma** due to cerebral edema

Signs of hypo / hypervolaemia:

Signs of …

Volume depletion	Volume overload
Postural hypotension	**Hypertension**
Tachycardia	**Tachycardia**
Absence of JVP @ 45^{o}	**Raised JVP / gallop rh**
Decreased skin turgor	**Oedema**
Dry mucosae	**Pleural effusions**
Supine hypotension	**Pulmonary oedema**
Oliguria	**Ascites**
Organ failure	**Organ failure**

Treatment of EW

- water restriction and infusion of isotonic or hypertonic saline solution
- In the SIADH secretion. Diagnosis of SIADH secretion is established when urine sodium > 20 mEq/L **when there is no renal failure, hypotension, and edema**. Treatment involves restriction of water intake (<1000 ml/day) and use of ADH- Antagonist (Demeclocycline 300-600 mg b.i.d).

Water Deficit:

- the most encountered derangement of fluid balance in surgical patients.
- Causes include Bleeding, third spacing, gastrointestinal losses, increase insensible loss (normal ≈ 10ml/kg/day), and increase renal losses (normal ≈ 500-1500 ml/day).

Symptoms and Signs of WD

- Symptoms of water deficit include feeling thirsty, dryness, lethargy, and confusion.
- Signs include dry tongue and mucous membranes, sunken eyes, dry skin, loss of skin turgor, collapsed veins, depressed level of conciousness, and coma.

Signs of hypo / hypervolaemia:

Signs of …

<u>Volume depletion</u>	<u>Volume overload</u>
Postural hypotension	
Tachycardia	
Absence of JVP @ 45^{o}	
Decreased skin turgor	
Dry mucosae	
Supine hypotension	
Oliguria	
Organ failure	

Diagnosis of WD

- Diagnosis can be confirmed by ↑ serum sodium (>145mEq/L) and ↑ serum osmolality (>300 mOsmol/L)

Tratment of WD

- If sodium is > 145mEq/L give 0.45% hypotonic saline solution,
- if sodium is >160mEq/L give D5%Water **cautiously and slowly** (e.g. 1liter over 2-4 hours) in order not to cause water excess.
- Bleeding should be replaced by IVF initially then by whole blood or packed red cells depending on hemoglobin level. Each blood unit will raise the hemoglobin level by 1 g.
- Third spacing replacement can be estimated within a range of 4-8 ml/kg/h.
- Gastrointestinal and intraoperative losses should be replaced cc/cc.
- IVF maintenance can be roughly estimated as 4/2/1 rule.

Hypercalcemia:

- Diagnosis is established by measuring the free Ca^{++} >10mg/dl.
- In surgical patients hypercalcemia is usually caused by hyperparathyroidism and malignancy.
- Symptoms of hypercalcemia may include confusion, weakness, lethargy, anorexia, vomiting, epigastric abdominal pain due to pancreatitis, and nephrogenic diabetes insipidus polyuria

Management of high Ca

- Diagnosis is established by measuring the free Ca^{++} >10mg/dl.
- Treatment includes normal saline infusion, and if CA^{++}>14mg/dl with ECG changes additional diuretics, calcitonin, and mithramycin might be necessary

Hypocalcemia:

- Results from low parathyroid hormone after thyroid or parathyroid surgeries,
- low vitamin D,
- **pseudohypocalcemia (low albumin and hyperventilation).**
- Other less common causes include pancreatitis, necrotizing fascitis, high output G.I. fistula, and massive blood transfusion.

Symptoms and signs of low Ca

- may include numbness and tingling sensation circumorally or at the fingers' tips. Tetany and seizures may occur at a very low calcium level. Signs include tremor, hyperreflexia, carpopedal spasms and positive Chvostek sign.

Treatment of low Ca

- Treatment should start by treating the cause. Calcium supplementation with calcium gluconate or calcium carbonate i.v. or orally. Vitamin D supplementation especially in chronic cases.

Hypomagnesaemia:

- The majority of magnesium is intracellular with only <1% is in extracellular space.
- It happens from inadequate replacement in depleted surgical patients with major GI fistula and those on TPN.
- **Magnesium is important for neuromuscular activities. (can not correct K nor Ca)**
- In surgical patients hypomagnesaemia is a frequently missed common electrolyte abnormality as **it causes no major alerting symptoms.**

Hypermagnesaemia:

- Mostly occur in association with renal failure, when Mg+ excretion is impaired.
- The use of antacids containing Mg+ may aggravate hypermagnesaemia.
- Treatment includes rehydration and renal dialysis.

Hypophosphataemia:

- This condition may result from :
  - -inadequate intestinal absorption,
  - -increased renal excretion,
  - -hyperparathyroidism,
  - - **massive liver resection**, and
  - -inadequate replacement after recovery from significant starvation and catabolism.

Management of low phos

- Hypophosphataemia causes muscle weakness and inadequate tissue oxygenation due to reduced 2,3-diphosphoglycerate levels.
- Early recognition and replacement will improve these symptoms.

Hyperphosphataemia:

- Mostly is associated with renal failure and hypocalcaemia due to hypoparathyroidism, which reduces renal phosphate excretion.

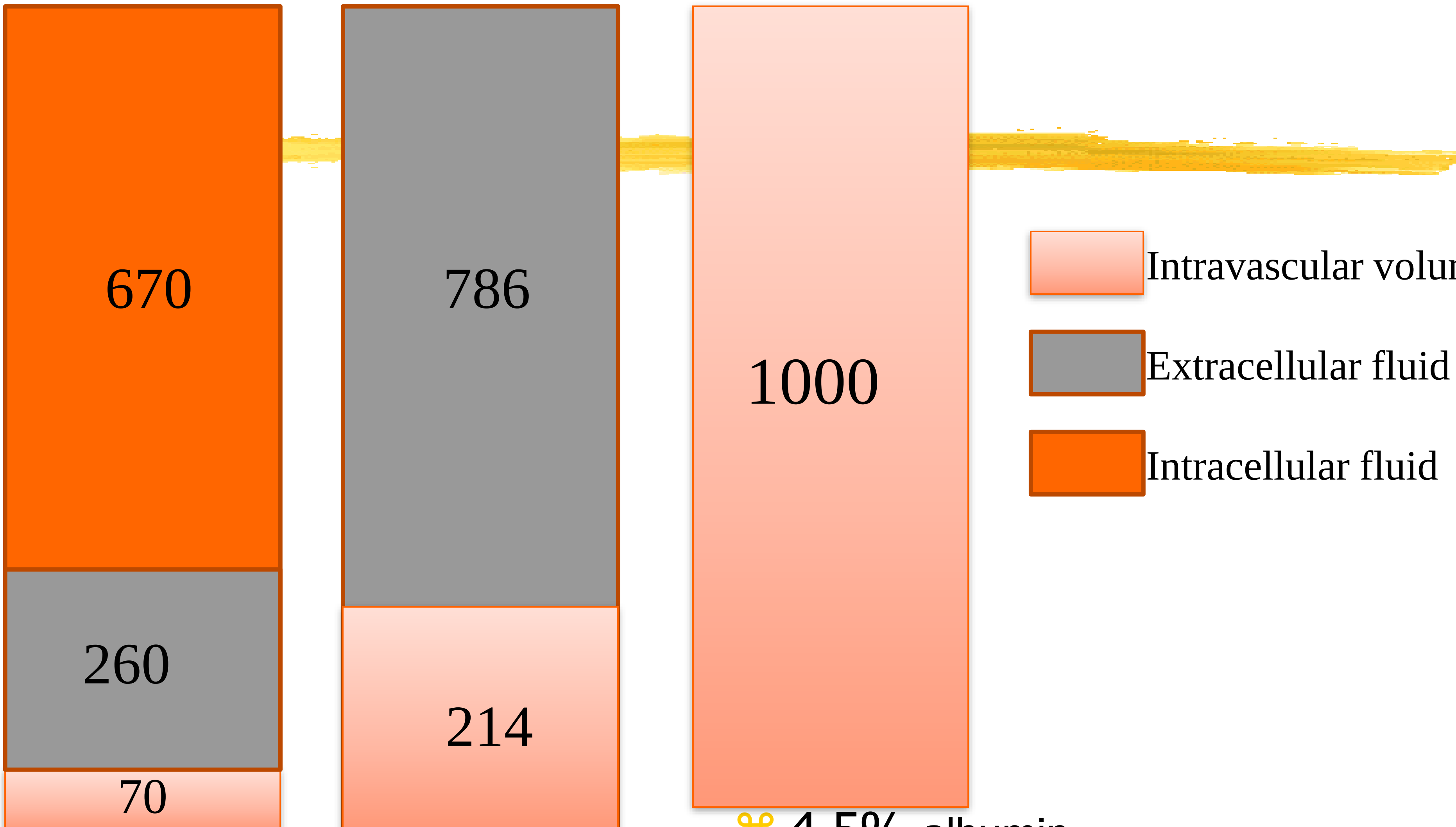
Prescribing fluids:

- Crystalloids:(iso, hypo, hypertonic)
  - 0.9% saline - not “ normal “ !
  - 5% dextrose
  - 0.18% saline + 0.45% dextrose
  - Others
- Colloids:
  - blood
  - plasma / albumin
  - synthetics

The rules of fluid replacement:

- Replace blood with blood
- Replace plasma with colloid
- Resuscitate with colloid
- Replace ECF depletion with saline
- Rehydrate with dextrose

Principles of surgical care

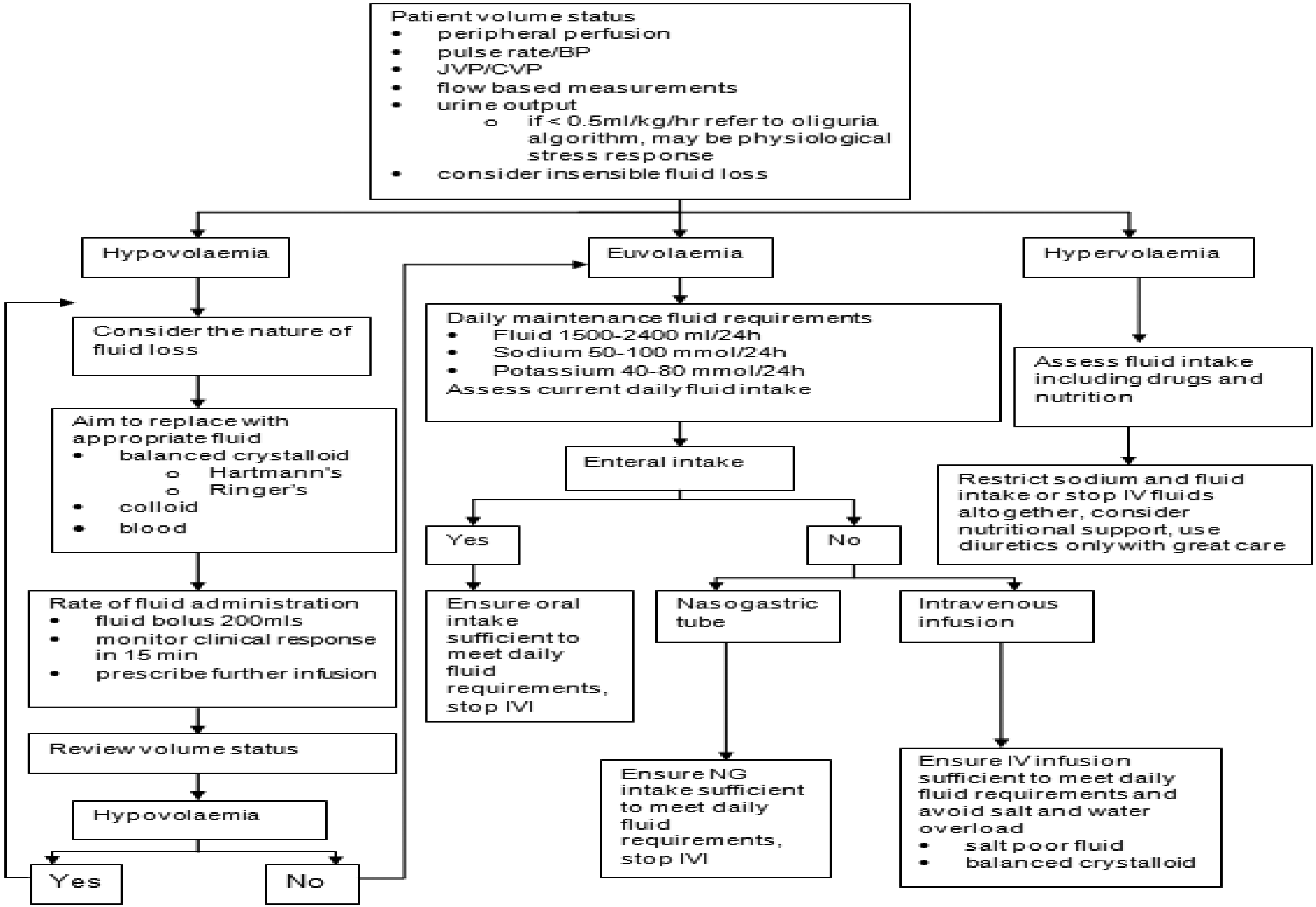


- 5% dextrose

0.9% NaCl
ringer,s lactate
Hartmann’s solution

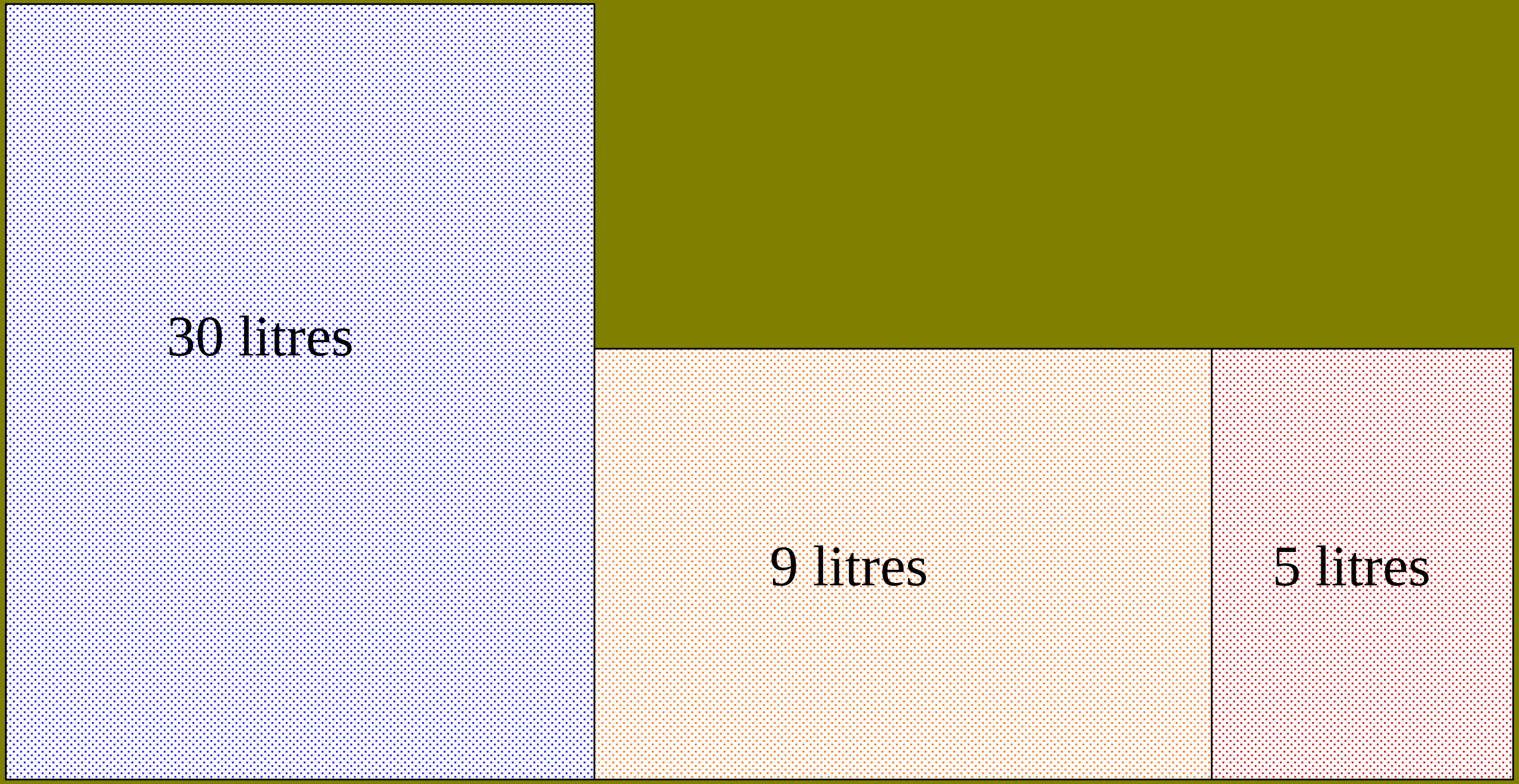
- 4.5% albumin
- Starches
- Gelofusine
- haemaccel

Guidelines for fluid therapy



Crystalloids & colloids

Crystalloids & colloids



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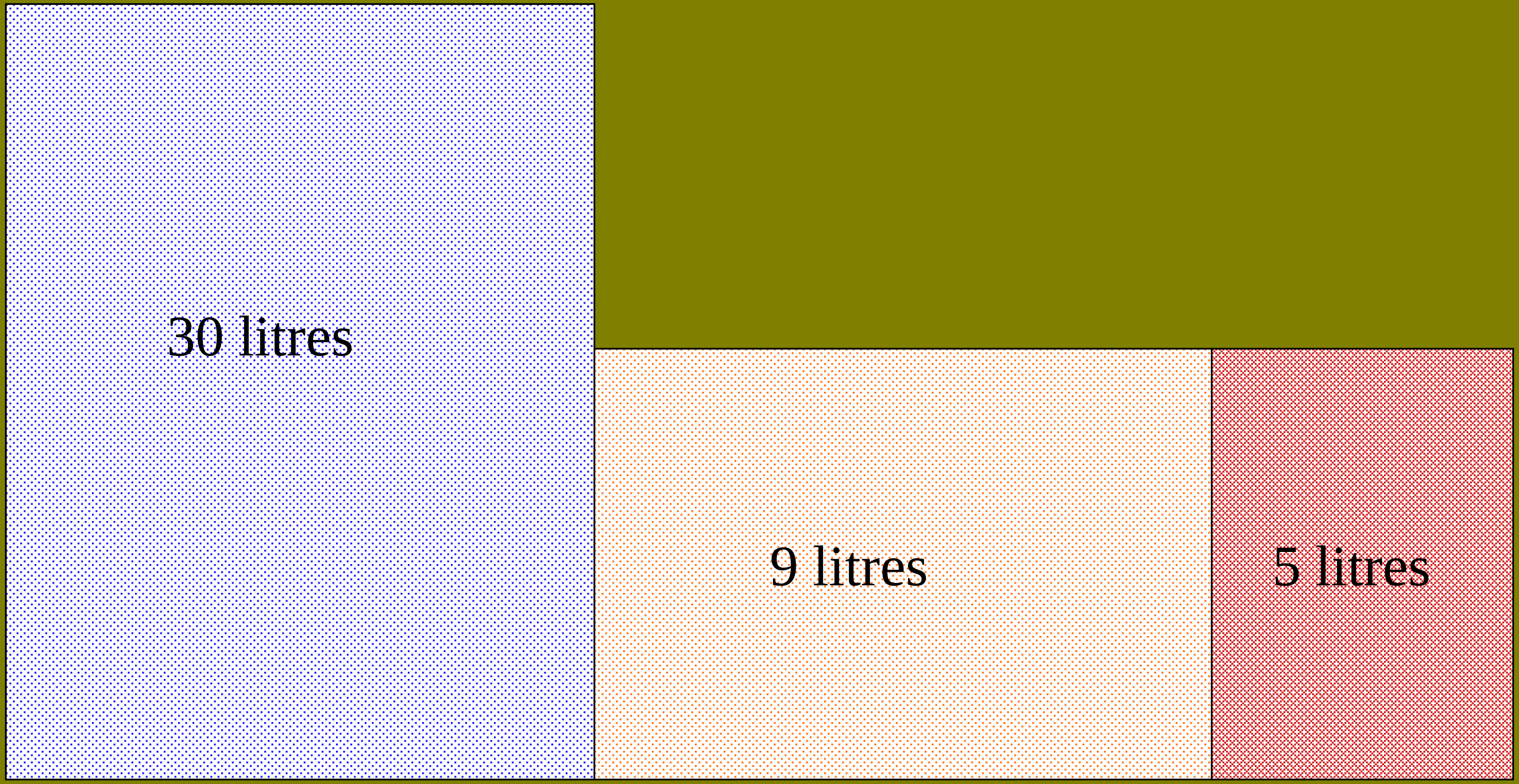

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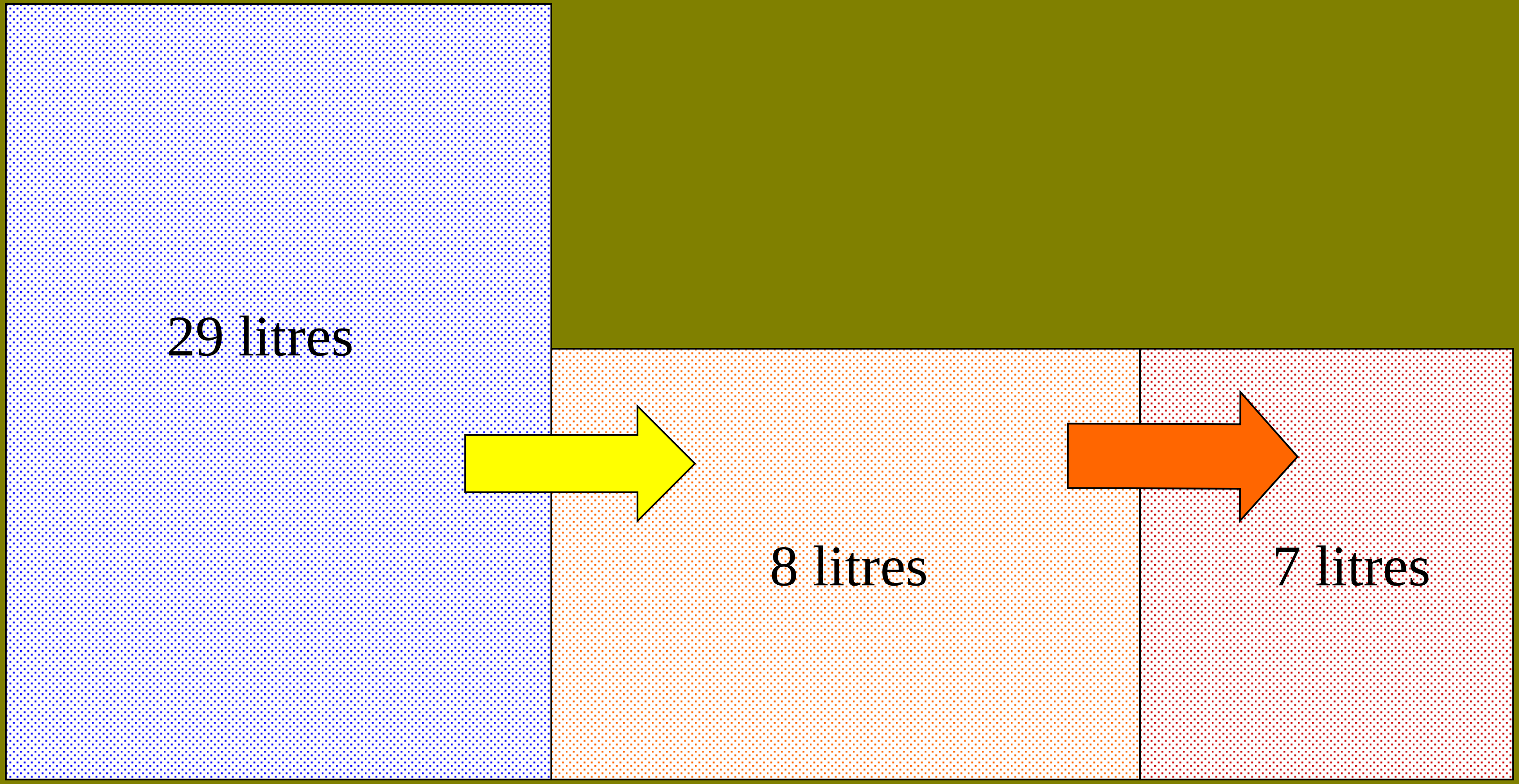

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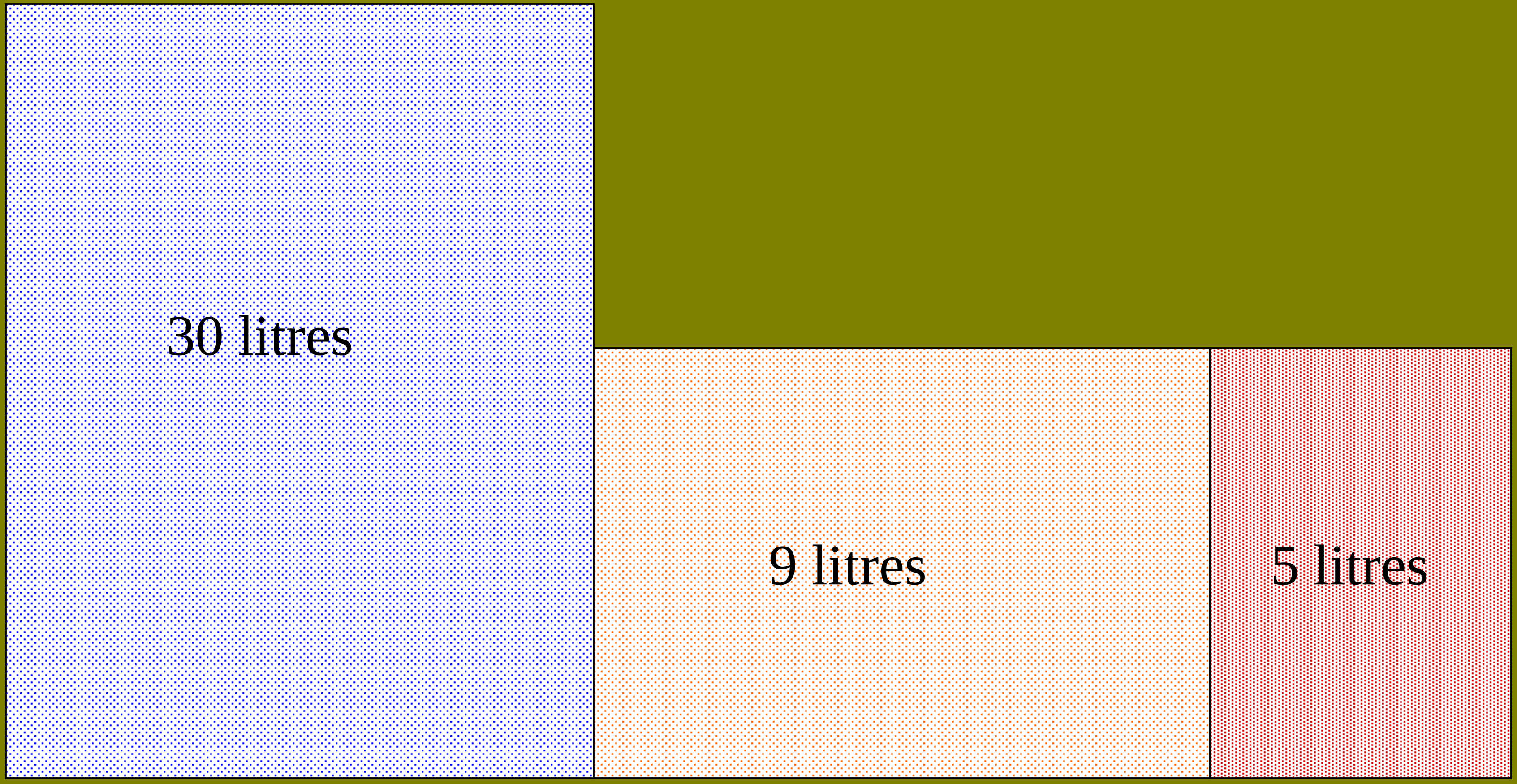

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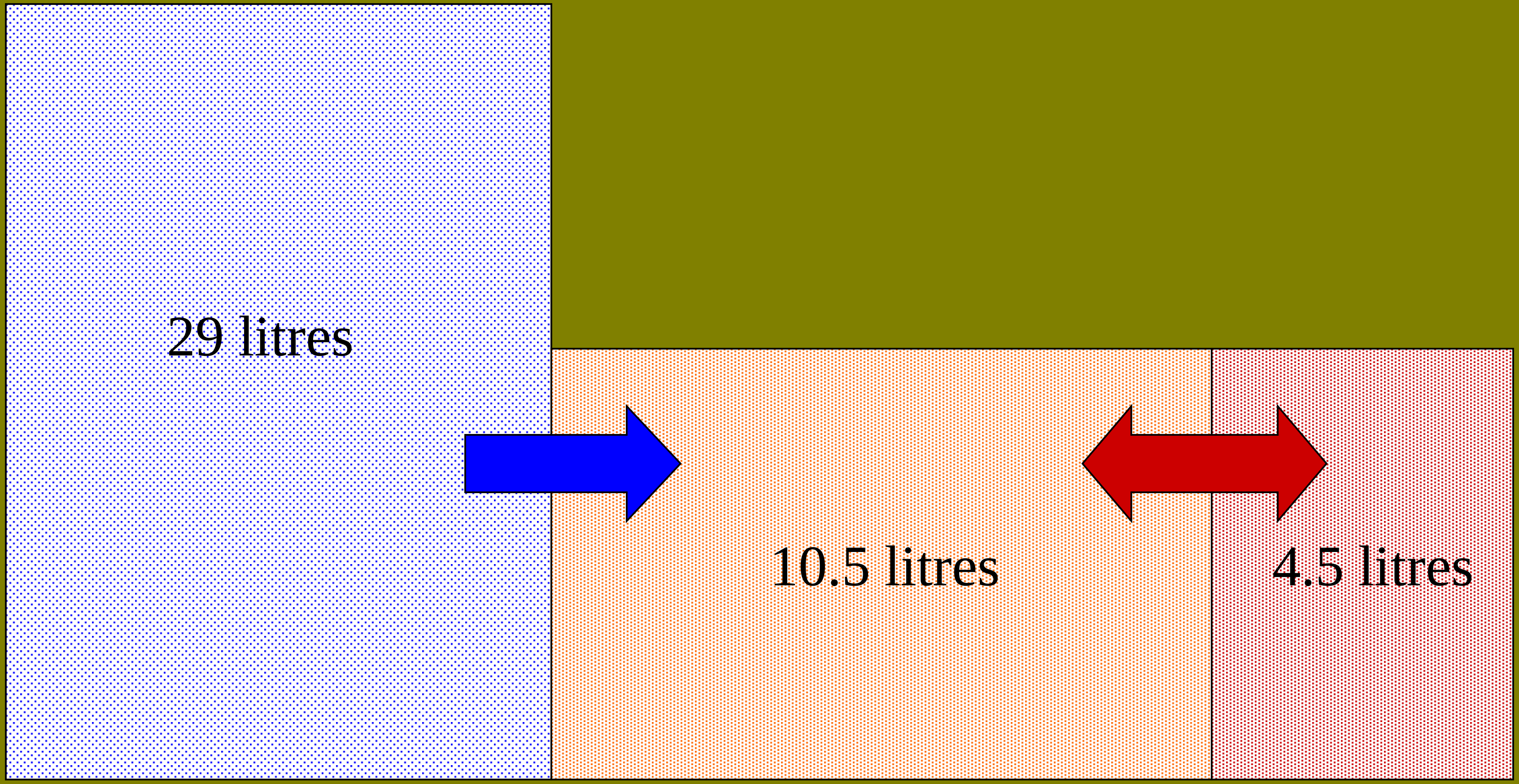

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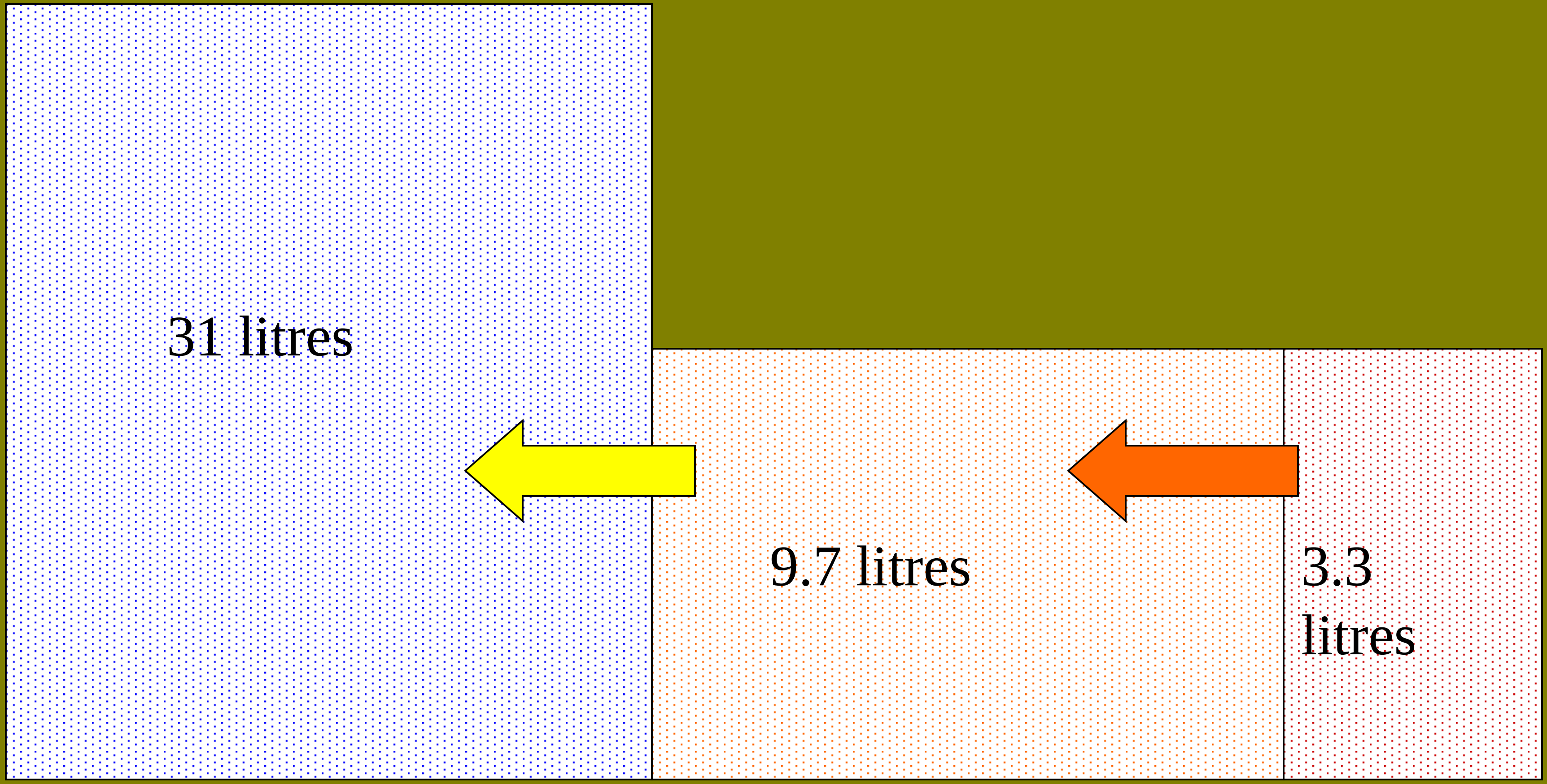

How much fluid to give ?

- What is your starting point ?
  - Euvolaemia ? (normal)
  - Hypovolaemia ? (dry)
  - Hypervolaemia ? (wet)
- What are the expected losses ?
- What are the expected gains ?

What are the expected losses ?

- Measurable:
  - urine (measure hourly if necessary)
  - GI (stool, stoma, drains, tubes)
- Insensible:
  - sweat
  - exhaled

What are the potential gains ?

- Oral intake:
  - fluids
  - nutritional supplements
  - bowel preparations
- IV intake:
  - colloids & crystalloids
  - feeds
  - drugs

Examples:

- What follows is a series of simple - and some more complex fluid-balance problems for you
- Answers are in the speakers notes.

Case 1:

- A 62 year old man is 2 days post-colectomy. He is euvolaemic, and is allowed to drink 500ml. His urine output is 63 ml/hour:

1. How much IV fluid does he need today ?
2. What type of IV fluid does he need ?

Case 2:

- 3 days after her admission, a 43 year old woman with diabetic ketoacidosis has a blood pressure of 88/46 mmHg & pulse of 110 bpm. Her charts show that her urine output over the last 3 days was 26.5 litres, whilst her total intake was 18 litres:

1. How much fluid does she need to regain a normal BP ?
2. What fluids would you use ?

Case 3:

- An 85 year old man receives IV fluids for 3 days following a stroke; he is not allowed to eat. He has ankle oedema and a JVP of +5 cms; his charts reveal a total input of 9 l and a urine output of 6 litres over these 3 days.

1. How much excess fluid does he carry ?
2. What would you do with his IV fluids ?

Case 4:

- 5 days after a liver transplant, a 48 year old man has a pyrexia of 40.8^{o}C. His charts for the last 24 hours reveal:
- urine output: 2.7 litres
- drain output: 525 ml
- nasogastric output: 1.475 litres
- blood transfusion: 2 units (350 ml each)
- IV crystalloid: 2.5 litres
- oral fluids: 500 ml

Case 4 cont:

- On examination he is tachycardic; his supine BP is OK, but you can’t sit him up to check his erect BP. His serum [Na+] is 140 mmol/l.

- How much IV fluid does he need ?
- What fluid would you use ?

Acid-Base balance

Normal physiology

- Hydrogen ion is generated in the body by:

  1-Protein and CHO metabolism (1meq/kg of body weight)

  2-Predominant CO_2 production
- It is mainly intracellular
- **PH depends on** $\mathbf{\dfrac{HCO_3}{CO_2}}$

Normal physiology

- PH = log 1/[H+]

- Normal PH range = 7.3 – 7.42

  PH<7.3 indicates acidosis

  PH>7.42 indicates alkalosis

Buffers

1- Intracellular

- Proteins
- Hemoglobin
- Phosphate

2- bicarbonate/carbonic acid system

$$H^+ + HCO_3 \leftrightarrow H_2CO_3 \leftrightarrow H_2O + CO_2$$

The main MECHANISM

HOW DO YOU READ A/VBG

- PH = 7.3-7.4
- Partial pressure of CO_2 in plasma (Pco_2) = 40 mmHg
- Partial pressure of O_2 in plasma (Po_2) = 65 mmHg
- Bicarbonate concentration (HCO_3) = 24 mEq/L
- O_2 Saturation ≥ 90%
- Base Excess 2.5 mEq/L (<2.5 metabolic acidosis, >2.5 metabolic alkalosis)
- Anion Gap (Na+ - [HCO3+Cl]) = 12 (>12 met. acidosis, < 12 met. alkalosis)

Anion Gap

- AG= Cations (NA+ K) – Anions (CL + HCO3)
- Normal value is 12 mmol
- Metabolic acidosis with:

  1-Normal AG (Diarrhea, Renal tubular acidosis)

  2-High AG ,

    -Endogenous(Renal failure, diabetic acidosis, sepsis)

    -Exogenous (aspirin, methanol, ethylene glycol)

Acid-base disorders

- Metabolic acidosis
- Respiratory acidosis
- Respiratory alkalosis
- Metabolic alkalosis

Causes of metabolic acidosis

Lactic acidosis

- Shock (any cause)
- Severe hypoxaemia
- Severe haemorrhage/anaemia
- Liver failure

Accumulation of other acids

- Diabetic ketoacidosis
- Acute or chronic renal failure
- Poisoning (ethylene glycol, methanol,salicylates)

Increased bicarbonate loss

- Diarrhoea
- Intestinal fistulae

Causes of metabolic alkalosis

- Loss of sodium, chloride, water: vomiting, NGT, LASIX
- hypokalaemia

Causes of respiratory acidosis

Common surgical causes of respiratory acidosis

Central respiratory depression

- Opioid drugs
- Head injury or intracranial pathology

Pulmonary disease

- Severe asthma
- COPD
- Severe chest infection

Causes of respiratory alkalosis

Causes of respiratory alkalosis

- Pain
- apprehension/hysterical hyperventilation
- Pneumonia
- Central nervous system disorders(meningitis, encephalopathy)
- Pulmonary embolism
- Septicaemia
- Salicylate poisoning
- Liver failure

Type of A- B disorder	**Acute (Uncompensated)**			**Chronic (Partially compensated)**		
	PH	PCO2	HCO3	PH	PCO2	HCO3
Respiratory acidosis	↓↓	↑↑	Normal	↓	↑↑	↑
Respiratory alkalosis	↑↑	↓↓	Normal	↑	↓↓	↓
Metabolic acidosis	↓↓	Normal	↓↓	↓	↓	↓
Metabolic alkalosis	↑↑	Normal	↑↑	↑	↑	↑

The End