FLUID AND ELECTROLYTES

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ADVANCES IN MANAGEMENT OF NEONATAL DISORDERS HAVE GREATLY DECREASED THE MORBIDITY AND MORTALITY IN THE PRETERM POPULATION.

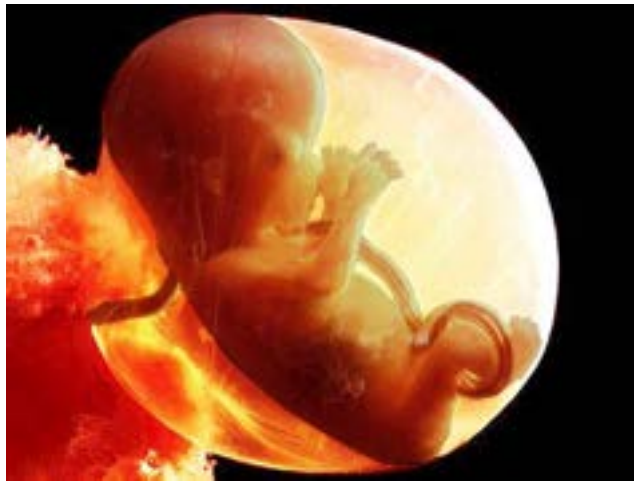
SUPPORTIVE NEONATAL INTENSIVE CARE

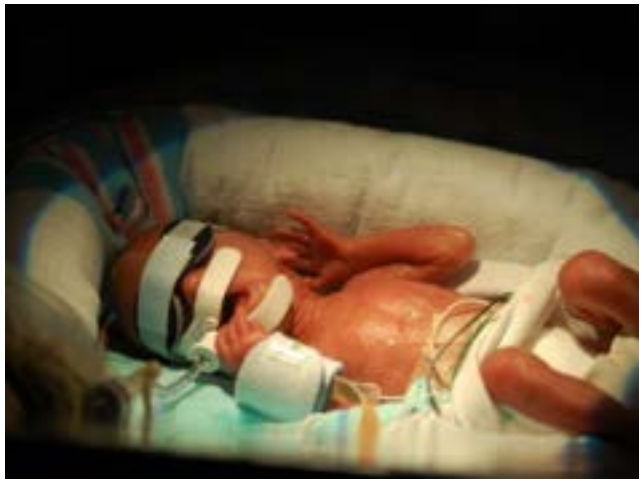
- Fluid and electrolyte therapy
- Thermal regulation
- Maintenance of oxygenation

The assessment of body water metabolism and electrolyte balance plays an important role in the early management of the preterm and sick infant in the NICU

BODY FLUID COMPOSITION

In utero –
100% aquatic





24 weeks – 90%

32 weeks – 83%

40 weeks – 80%

BODY FLUID COMPOSITION

Body Water Compartments	24 wk GA	32 wk GA	Term	3 mos of age	1 yr of age
TBW	90	83	80	70	65
ECF	65	53	45	35	20
ICF	25	30	35	35	45

TBW = ECF + ICF

FANAROFF & MARTIN, 2011

COMPARTMENTALIZATION OF TOTAL BODY WATER

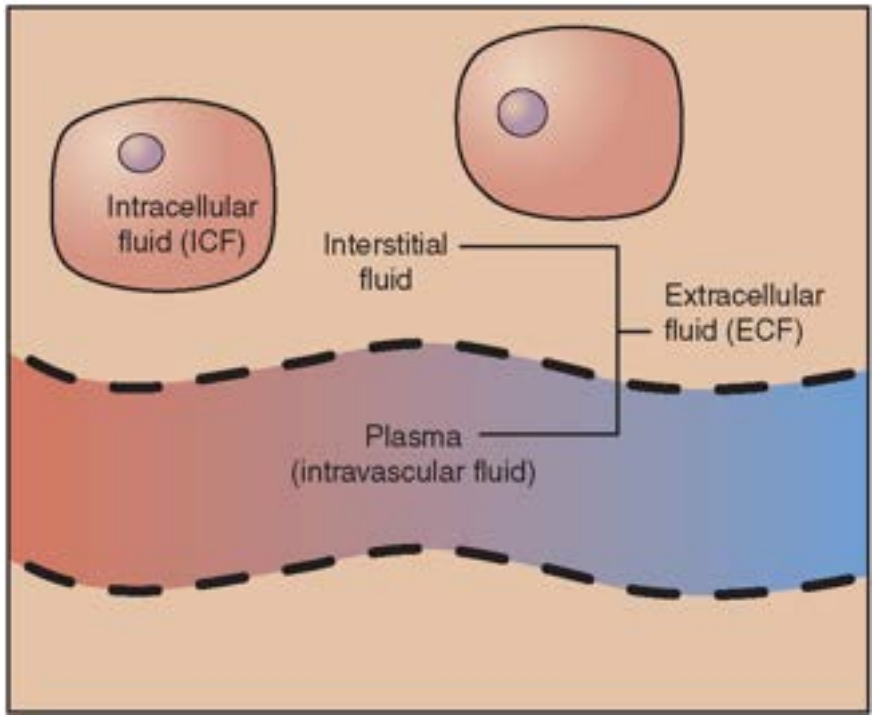
Intracellular Water (ICW)

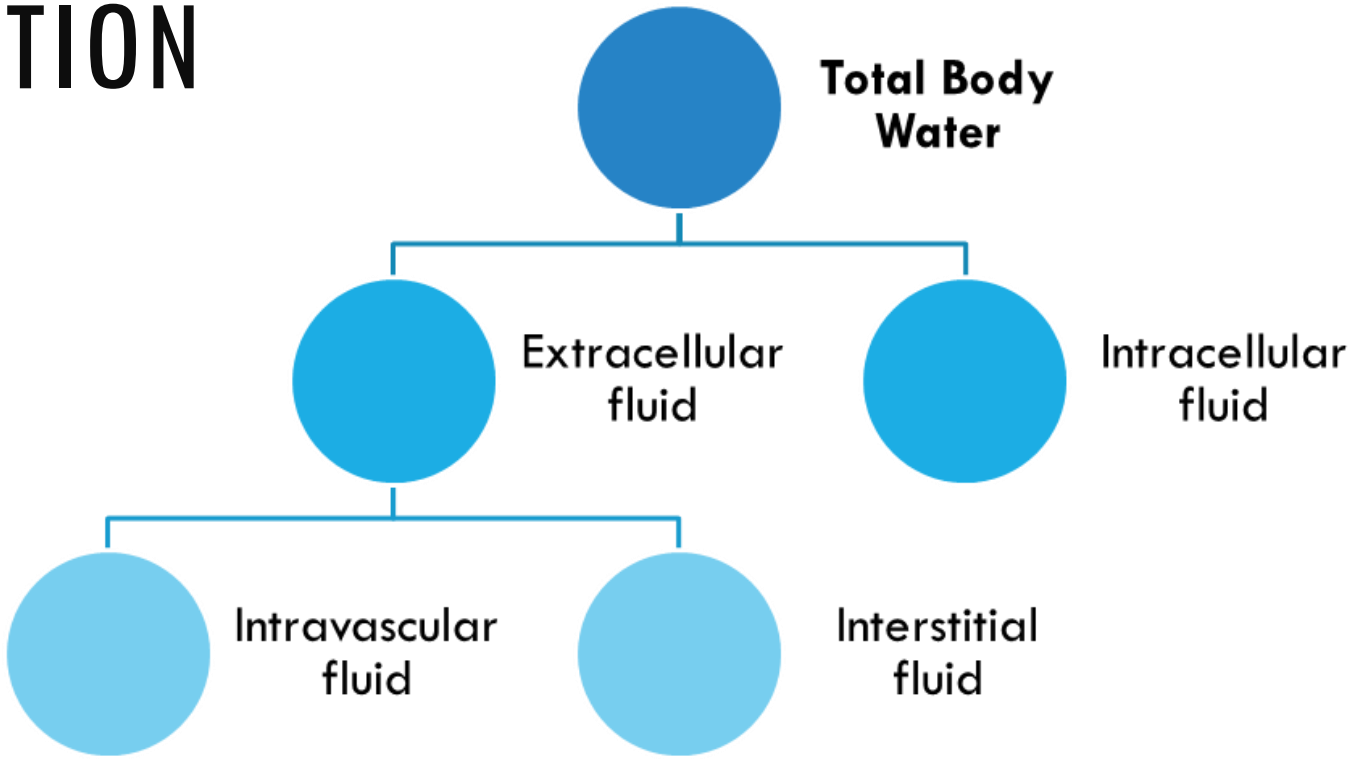
- Total amount of water inside the cell

Extracellular Water (ECW)

- Total amount of water outside the cell
  - Intravascular space
  - Interstitial space

BODY FLUID COMPOSITION





HTTP://WHAT-WHEN-HOW.COM/NURSING/FLUID-AND-ELECTROLYTE-BALANCE-STRUCTURE-AND-FUNCTION-NURSING-PART-1/

MONITORING TOTAL BODY WEIGHT (TBW) BALANCE

- Body weight
- Physical Exam
- Vital Signs
- Hct
- Serum Chemistry
- Acid-Base balance
- Urine

EXTRACELLULAR TO INTRACELLULAR

The ratio of ECW to ICW also changes with gestational age.

ECW decreases to 60% of TBW in 2nd trimester and 45% at term.

ICW increases to 25% by 2nd trimester and 33% by term

NORMAL PHYSIOLOGIC WEIGHT LOSS

Normal changes

- Decreased TBW-increased ICF and decreased ECF

Term infants

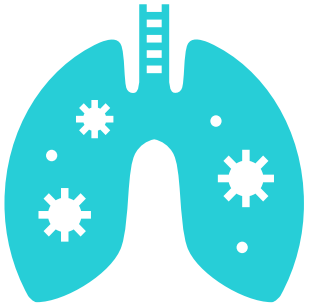
- Lose up to 5-10% of birthweight in first 5 days
- Expect weight gain reflecting growth by 10 days

Preterm infants

- Lose up to 10-20% of birthweight
- Expect weight gain that reflects growth by 2 (preterm) to 3 (VLBW) weeks

INSENSIBLE WATER LOSS

Evaporation of non-measurable water losses



Major routes:

Skin-up to 70%, Respiratory tract up to 30%

FACTORS AFFECTING INSENSIBLE WATER LOSS

Increasing IWL

- Decreased gestational age and or birthweight
- Increased environmental temperature above NTE or body temp
- Skin breakdown
- Congenital skin defects such as:
  - Omphalocele
  - Gastroschisis
  - NTD
  - Epidermolysis bullosa
- Radiant warmer
- Phototherapy

FACTORS AFFECTING INSENSIBLE WATER LOSS

Decreased IWL

- Humidity
- Use of plastic heat shield or double-walled isolette

The distribution of TBW between intracellular and extracellular spaces depends on the water's relative content of solutes (electrolytes, proteins) or osmolality.

Osmolality is determined by number of solute particles.

Cell membranes are completely permeable to water, but not to most solutes.

Water shifts from one compartment to another until equilibrium is achieved.

The osmolality of intracellular and extracellular spaces is therefore equal, although the composition of ICW and ECW are different.

Appropriate administration of fluids is important because both excessive fluid restriction and fluid overload lead to clinical consequences.

RENAL WATER LOSS

Preterm infants have immature Na and water homeostasis due to:

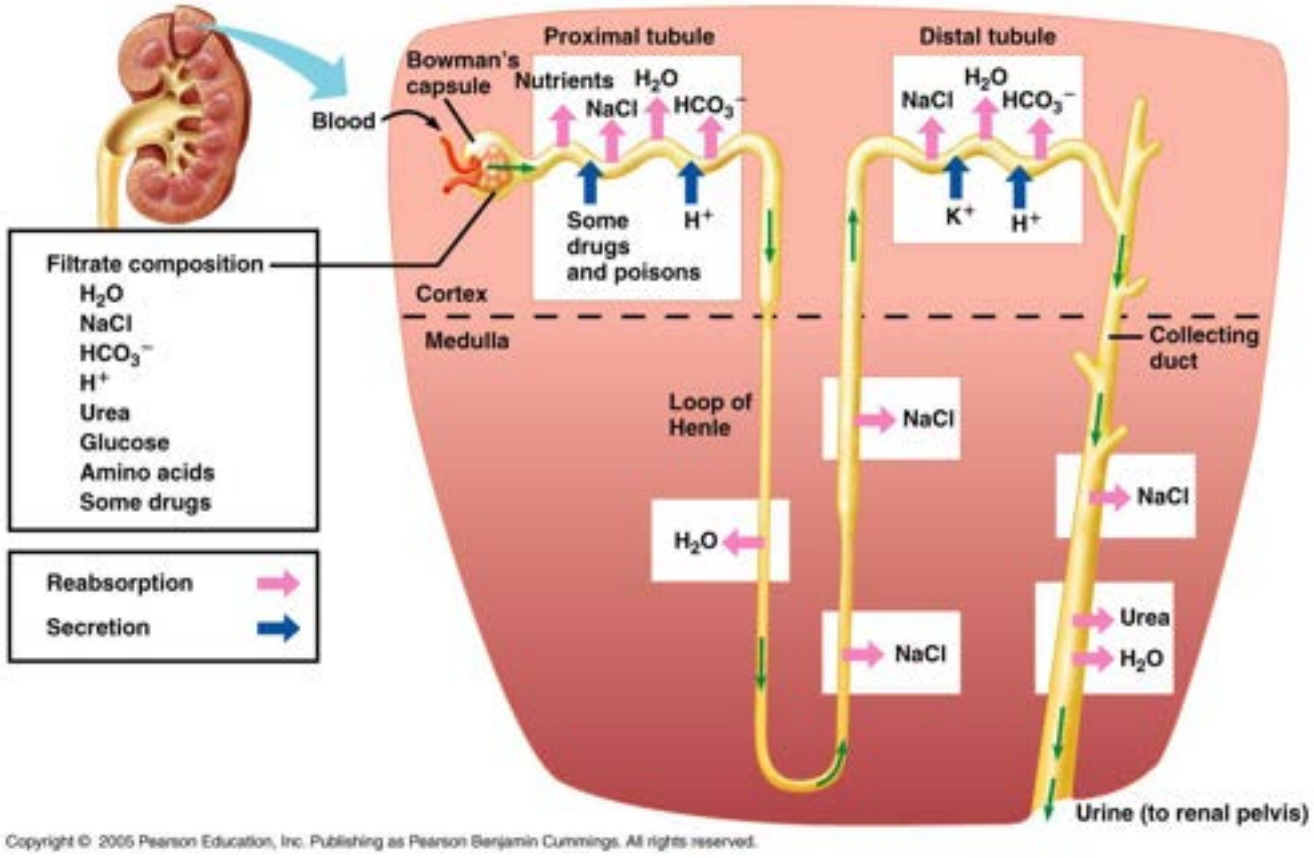
- Decreased glomerular filtration rate
- Reduced proximal/distal tubule reabsorption
- Ability to concentrate urine is reduced
- Decreased bicarbonate, potassium, and hydrogen ion secretion

Renal function matures with age

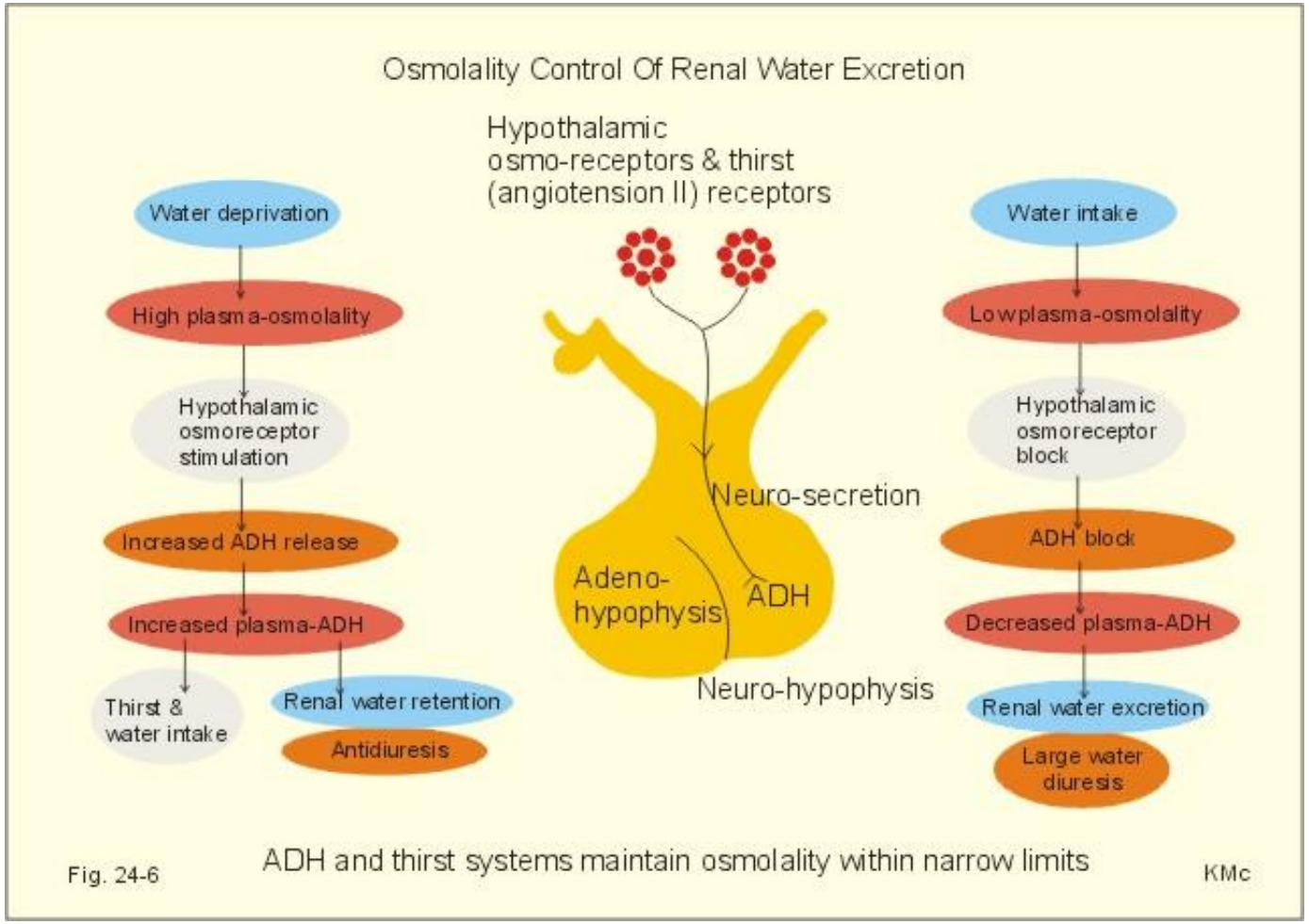
ENDOCRINE CONTROL OF WATER METABOLISM

Antidiuretic hormone (ADH) or arginine vasopressin

- Syndrome of inappropriate ADH secretion (SIADH)
- Nephrogenic diabetes insipidus (DI)



OSMOLALITY CONTROL OF RENAL WATER EXCRETION



SIADH VS DI


SIADH VS DI
SIADH
"Soaked Inside"
STOP
DI
"Dry Inside"
SimpleNursing

MAINTENANCE FLUID REQUIREMENTS

Birthweight (gm)	IWL (ml/kg/day)	DOL 1-2	DOL 3-7	DOL 8-30
< 750	100 +	100 – 200	120 – 200	120 – 180
750 – 1000	60 – 70	80 – 150	100 – 150	120 – 180
1001 – 1500	30 – 65	60 – 100	80 – 150	120 – 180
> 1500	15 – 30	60 – 80	100 – 150	120 – 180

TF = IWL + Sensible Water Loss + Growth

FACTORS AFFECTING FLUID REQUIREMENTS

Maternal History	Placental Dysfunction due to PIH	Leads to IUGR
	Poorly controlled Diabetes	Renal vein thrombosis-affects renal function
	Maternal steroids	Increases skin maturation
	Medications	Oxytocin
		Hypotonic IVF

FACTORS AFFECTING FLUID REQUIREMENTS

Newborn History	Oligohydramnios	
	Renal Dysfunction	Renal Agenesis(Potters Syndrome)
		Polycystic Kidney Disease
		Post Urethral Valves
	Hypoxemia	
	Acute Tubular Necrosis	
	Environment	Humidity (decreased IWL)
		Warmer (increased IWL)
	Phototherapy (increased IWL)	

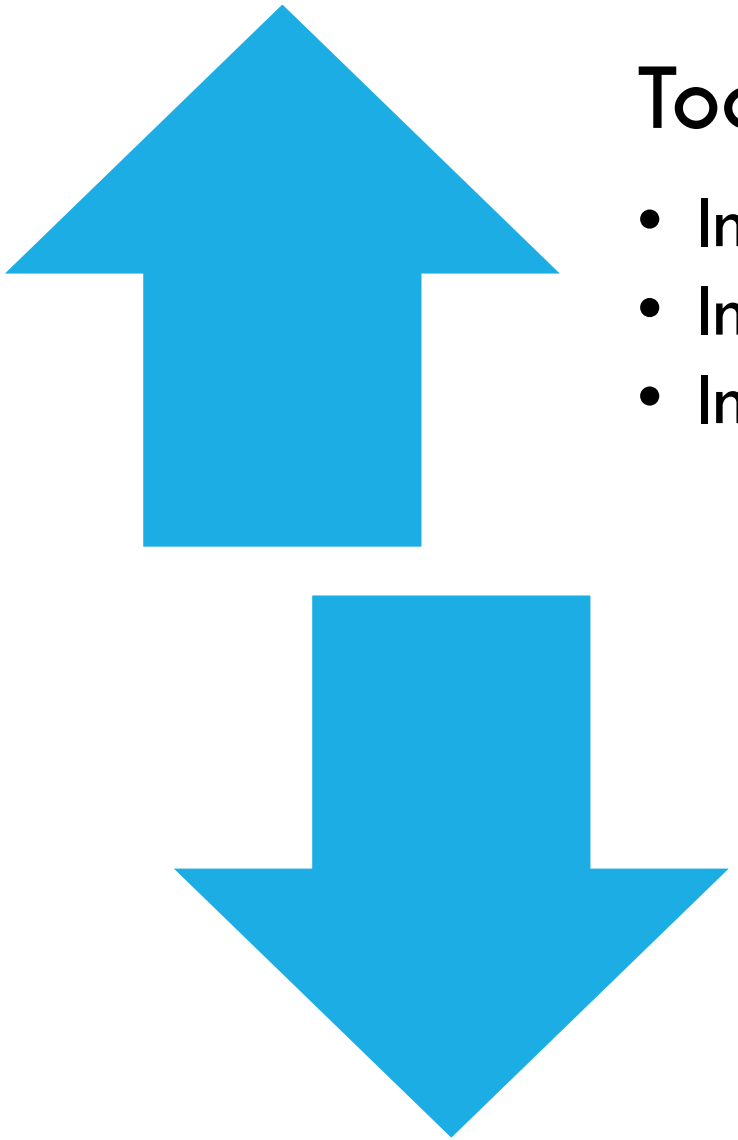
FLUID MANAGEMENT

IV fluids given during the first days of life are a major factor in the development or prevention of morbidities.

- IVH
- NEC
- PDA
- BPD

It is crucial that we pay close attention to the details of maintaining body water and serum electrolytes.

Body fluid balance is a function of the distribution of water in the body, water intake and water losses.



Too Much Fluid

- Increase in PDA's
- Increase BPD
- Increase NEC

Too Little Fluid

- Dehydration
- Hyperosmolarity
- Hypoglycemia
- Hyperbilirubinemia

WHERE DOES IT ALL GO?

- Warmers – 20-30 cc/kg/day
  - Humidity adds back 30% of fluid loss
- Phototherapy – 20-30 cc/kg/day
- Urine – 25-50 cc/kg/day
- Stool – 5-10 cc/kg/day

AFFECTS OF COMMON DISEASE STATES ON FEN MANAGEMENT

HIE

- Restrict fluids to <60ml/kg/day
  - Avoid fluid overload, potentially worsening cerebral edema
- Initially limit K and during recovery need to replace Na

RDS

- Individualize fluids

AFFECT OF COMMON DISEASE STATES ON FEN MANAGEMENT

PDA

- Avoid fluid overload
- Be careful with pharmacologic therapy and impact on renal function

CLD

- Avoid fluid overload
  - Balance fluid needs and increased caloric needs
- Be careful with diuretic therapy
  - Watch for electrolyte abnormalities
  - Screen for osteopenia

AFFECT OF COMMON DISEASE STATES ON FEN MANAGEMENT

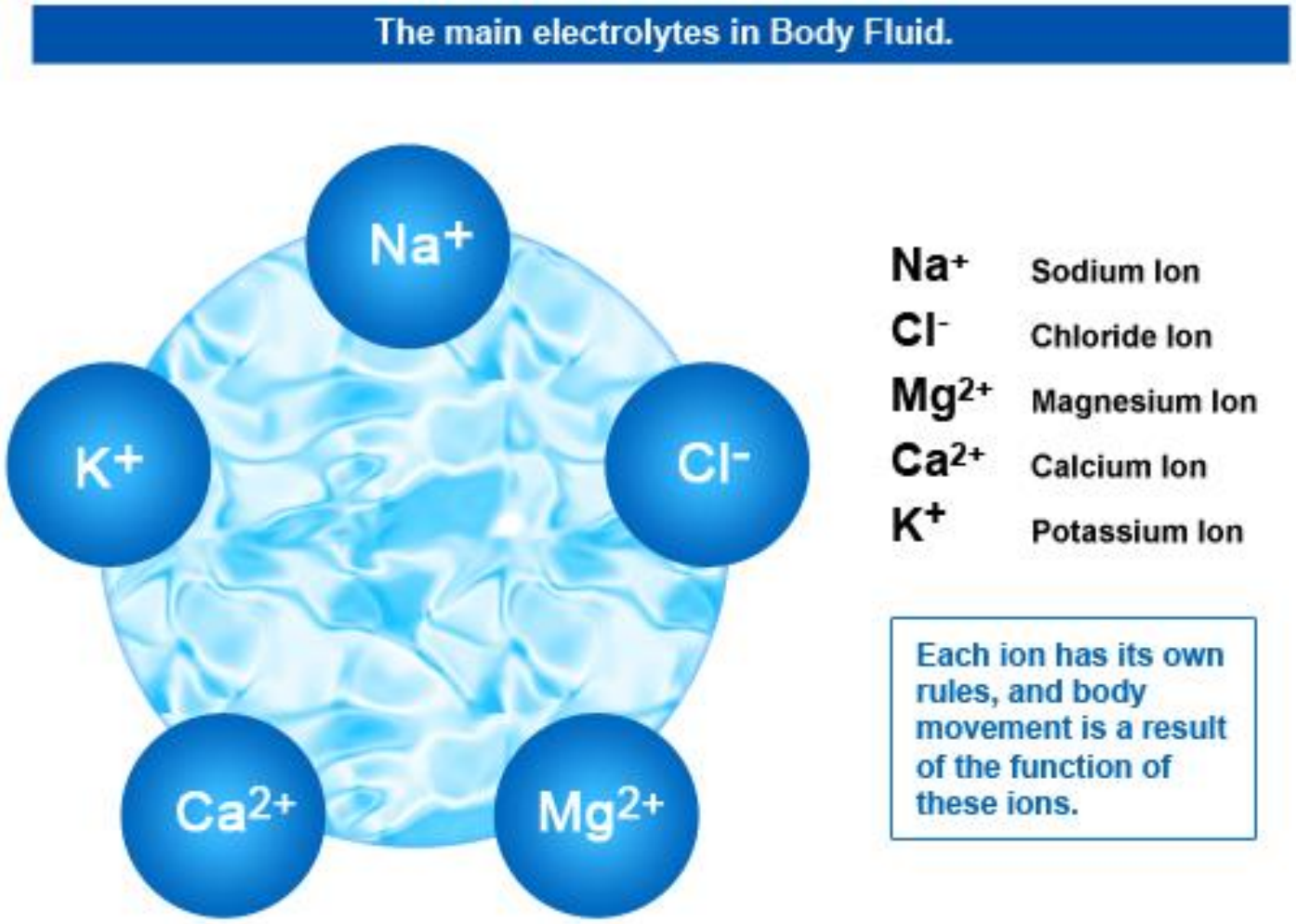
Abdominal wall defects

- Need increased TF secondary to IWL

Post abdominal surgery

- Increased TF due to 3rd spacing
- With 3rd spacing, intravascular fluids leak into tissue and bowel wall lumen

ELECTROLYTES



HTTP://MEDIFITBIOLOGICALS.COM/ELECTROLYTES/

BMP

Na	Cl	BUN	Ca
K	CO2	Creatinine	Glucose
135-145	97-110	3-25	8-11
3.5-5.5	20-28	0.3-1	> 40

Normal Serum Values

SODIUM

- The main extracellular cation
- Normal requirements:
  - Initial phase:
    - 0-1mEq/kg/day
  - Prediuretic phase:
    - 2-3mEq/kg/day
  - Post diuretic phase:
    - 3-5mEq/kg/day

HYPONATREMIA

Evaluation

- H&P
- Weight pattern
- Total intake and output
- Lab studies
  - Serum sodium and osmolarity
  - Urine for sodium, osmolality and sg
  - CMP/BMP
  - Imaging

HYPONATREMIA

Serum Na < 130mEq/L

DDX:

- Factitious
- Normal ECF
  - Excessive fluid administration (dilutional)
  - SIADH
- Inadequate sodium intake
- Medication related
  - Neuromuscular paralysis
  - Indomethacin therapy
  - Diuretic therapy

HYPONATREMIA

DDx (continued):

- ECF excess (hypervolemia)
  - CHF
  - Sepsis
  - Renal or liver failure
  - NEC (late)

- ECF deficit
  - Renal losses
  - GI losses, 3rd spacing

HYPONATREMIA MANAGEMENT

Asymptomatic hyponatremia management is based on underlying cause:

- Replace deficits-including maintenance
  - Inadequate Na intake
  - Medication related
- Restrict fluids
  - SIADH
  - Volume overload

HYPONATREMIA MANAGEMENT

Symptomatic hyponatremia is a medical emergency

- 3% hypertonic sodium chloride
- Replace slowly
- Monitor labs and vital signs closely
- Monitor for fluid overload
- Pulmonary edema

HYPERNATREMIA

Serum Na > or = to 150mEq/L

DDx:

- Hypovolemia
- Dehydration
- Excess Na intake
- Medication related

POTASSIUM

- The main intracellular ion
  - Role: maintain normal cardiac rhythm, skeletal muscle contraction, acid-base balance and transmission/conduction of nerve impulses
- Normal requirements
  - Added once UOP is established
  - Initial phase: none
  - Prediuretic phase: 1-2 mEq/kg/day
  - Post diuretic phase 2-3 mEq/kg/day

HYPOKALEMIA

Serum K < 3mEq/L

DDx:

- Decreased intake
- Renal losses
- GI losses
- Medication related
- Metabolic alkalosis
- Endocrinopathies

HYPOKALEMIA

Diagnostic evaluation:

- Physical exam
- Lab studies
  - Repeat central potassium level
  - Random urine for electrolytes
  - CMP with mag level
  - Blood gas
  - Endocrine studies
  - Imaging
  - EKG

HYPOKALEMIA MANAGEMENT

Management is based on underlying cause:

Emergency correction:
0.5-1mEq/kg/dose over 30-60 min

If symptomatic but not life threatening:
correct over 12-24hrs

HYPERKALEMIA

Central serum K>6.5 mEq/L

- Check for EKG changes

DDx:

- Factitious
- Increased K+ load
  - Give too much
  - Bleeding or hemolysis
  - PRBC or exchange transfusion
- Decreased K+ removal or excretion
  - Acute renal failure
  - CAH
  - Immature renal function in ELBW

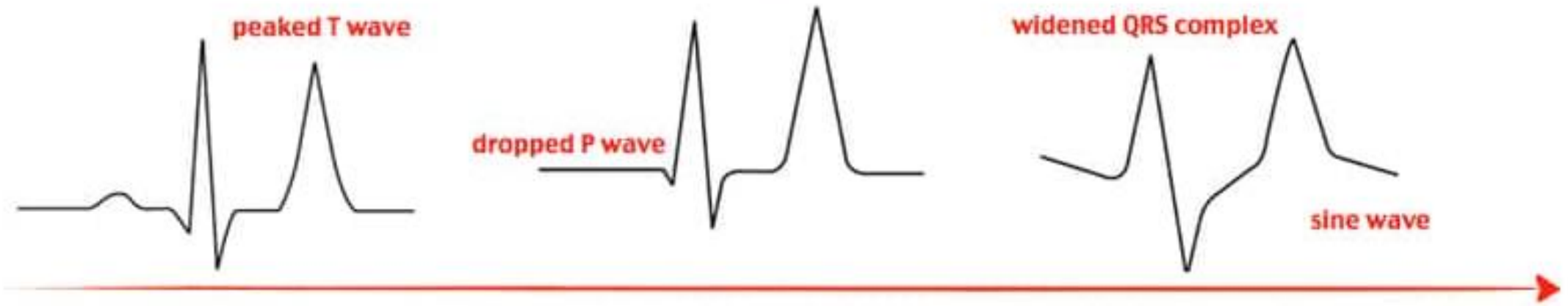
Diagnostic evaluation:

- Physical exam
- Lab studies
  - Venous serum sample
  - Serum and urine electrolytes
- EKG

HYPERKALEMIA

HYPERKALEMIA MANAGEMENT

Hyperkalemia with EKG changes is a medical emergency



HYPERKALEMIA MANAGEMENT

10% Calcium gluconate	NaBicarb	Insulin/glucose (D10) infusion	Albuterol
• 100mg/kg/dose given over 10-15 min, preferably in central line	• 1-2 mEq/kg/dose over 10-30 min	• D10W 2-3 ml/kg/dose over 10-30 min • 0.05-0.1 U/kg/dose bolus then continuous insulin infusion	• 0.1-0.5 mg/kg/dose

HYPERKALEMIA MANAGEMENT

Lasix

- 2 mg/kg/dose q 12hrs IV or 4 mg/kg/dose q 12hrs PO

Kayexalate-cation exchange resin

- Should not be used in ELBW infants
- 1 gm/kg intrarectally q 6hrs
- Last resort

Exchange transfusion/Dialysis

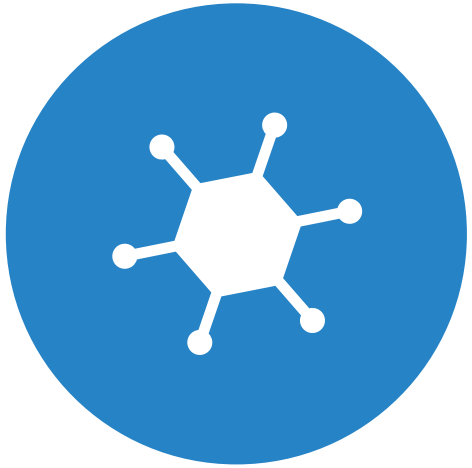
- Last resort

HYPERKALEMIA MANAGEMENT

Hyperkalemia without EKG changes:

- Remove all supplemental K+ from IV fluid and/or discontinue supplements
- Keep Ca and Mag levels in normal range
- Correct acidosis
- Ensure adequate fluid intake
- Consider Lasix

CHLORIDE



EXTRACELLULAR ANION

NORMAL SERUM LEVELS:
98-113 MEQ/L

HYPOCHLOREMIA

Serum levels <98 mEq/L

- DDx:
  - Decreased intake
  - Chloride losses

HYPERCHLOREMIA

Serum chloride levels > 110mEq/L

- Uncommon in newborn period

DDx:

- Excessive intake

SERUM CO2

- Measure of blood bicarbonate levels:
  - Low serum CO2 = metabolic acidosis
  - High serum levels = metabolic alkalosis

- Adding acetate as salt in preterm infants is done because of immature renal function

CALCIUM

- Extracellular ion
- Found in 2 compartments:
  - Skeletal (99%)
  - ECF (1% = bound + free calcium)
    - ECF: 40% protein bound, 50% free, and 10% inactivated
- Role:
  - Crucial for blood coagulation
  - Cellular activity
  - Cardiac function
  - Muscle contractility

CALCIUM

Normal total serum Ca values: 8.0-11.5 mg/dL

Balance between calcium and phosphorous:

- 1.3 : 1 ratio

HYPOCALCEMIA

Serum Ca < 7mg/dL

DDx - Early onset:

- Premature
- SGA
- HIE
- IDM

DDx - Late onset:

- Iatrogenic
- DiGeorge Syndrome
- Vit D deficiency
- High phosphate levels
- Diuretic therapy
- Hypoparathyroidism

HYPOCALCEMIA

Symptoms

Jittery
Apnea
Seizures

Treatment

Treat underlying cause
Calcium gluconate bolus
Maintenance calcium

HYPERCALCEMIA

Serum levels > 11-12mg/dL

Dxx:

- Iatrogenic
- Phosphate deficiency in preterm infants
- Inadequate Ca:Phos ratio in TPN
- Vitamin D overdose
- Adrenal insufficiency

HYPERCALCEMIA

Symptoms

- Hypotonia
- Irritability
- Poor feeding
- Arrhythmias
- Seizures

Treatment

- Discontinue calcium sources
- Hydration
- Lasix therapy
- Treat underlying causes

MAGNESIUM

- Intracellular Ion
- Normal serum Mag levels: 1.0-2.0
- Role:
  - Normal nerve and muscle function
  - Blood glucose levels
  - Blood pressure regulation

HYPOMAGNESEMIA

Serum Mag levels < 1

Rare, usually a result of hypercalcemia

Preterm and IUGR infants

Symptoms

- Tremors
- Hyperreflexia
- Hypocalcemia

Treatment

- Magnesium sulfate 25-50mg/kg/dose

HYPERMAGNESEMIA

Serum levels > 3mg/dL

DDx:

- Iatrogenic - maternal use during labor

Symptoms

- Hypotonia
- Respiratory insufficiency
- Apnea
- Decreased GI motility
- Poor feeding

Treatment

- Time
- If severe, may need calcium bolus

GENERAL NUTRITION PRINCIPLES

Goal: provide adequate calories to promote growth

Calories should be from non-protein calories

Factors that affect growth

- Gestational age
- Weight
- Thermal environment
- Activity
- Disease process

Preterm Goal: 110-140 kcal/kg/day for growth

GLUCOSE INFUSION RATE (GIR)

Calculating GIR: $\frac{\%\ \text{Dextrose} \times 0.167 \times \text{IV rate}}{\text{Weight (kg)}}$

Units: mg glucose/kg/min

Guidelines:

- Infants: Limit GIR to 12 – 14 mg/kg/min
- Children: Limit GIR to 7 – 12 mg/kg/min

GLUCOSE DELIVERY

1000 gram newborn getting 80/kg of Vanilla TPN

GIR 5.8

How did we get that answer?

3.5 (IV rate) x 10 (dextrose) divided by 6 (1(wt)x6)

Is this enough glucose for this baby?

CALCULATING GIR

1. 600 gram infant getting TPN with D12.5 @ 4cc/hr
2. 800 gram infant getting TPN with D15 @ 2cc/hr
3. 500 gram infant getting TPN with D10 @ 3cc/hr + D5 @ 1cc/hr
4. 3500 gram infant getting D10W @ 20cc/hr

CALCULATING TOTAL FLUIDS

1. 28 week, 1000 gram, one day old
2. 34 week, 2500 gram, three day old
3. 25 week, 500 gram, five day old
4. 39 week, 3000 gram, newborn being cooled
5. 30 week, 1750 gram, 2 week old

ELBW PREMATURE INFANT

- 500 gm newborn with UAC, UVC
  - UAC – ½ Na Acetate at 0.5 cc/hr
  - UVC – Vanilla TPN (D10) at 2 cc/hr
- Total fluids = 120 cc/kg/day
- 20% of fluids do not contain glucose
  - 6 lab draws/24 hrs = 6 cc flush = 12cc/kg/day
  - Medications/24 hrs = 12 cc flush + medication = 24cc/kg/day
  - Total fluid/24 hrs = 156 cc/kg/day = 30% without glucose

- What's the GIR?
- Is the baby getting enough fluid?
- What changes should be made?
- What is affecting his fluid balance?

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