Dehydration and fluid therapy

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Body composition

- TBW varies with age
- Water 50-75 % of body weight,more young age
- average 60 % : 40 % intracellular, 20 % extracellular .There is osmotic eq. between ICF,ECF freely permeable to water
- extracellular :(15% interstitial, 5 % blood)
- There is a balance between hydrostatic and oncotic pressure.
- Nephrotic syndrome (decrease OP): edema
- GN,heart failure :(increase HP) :edema

- Na ,CL main extracellular
- K, Phosphate main intracellular
- Serum electrolytes don't reflect total body stores…(DKA)

Blood osmolality (mmol/l)=2 × Na +glucose (mg/dl)/18 +BUN (mg/dl)/2.8

normal: 286-295

Urea : ineffective osmsole

In DKA: shifting of fluid cause hyponatremia

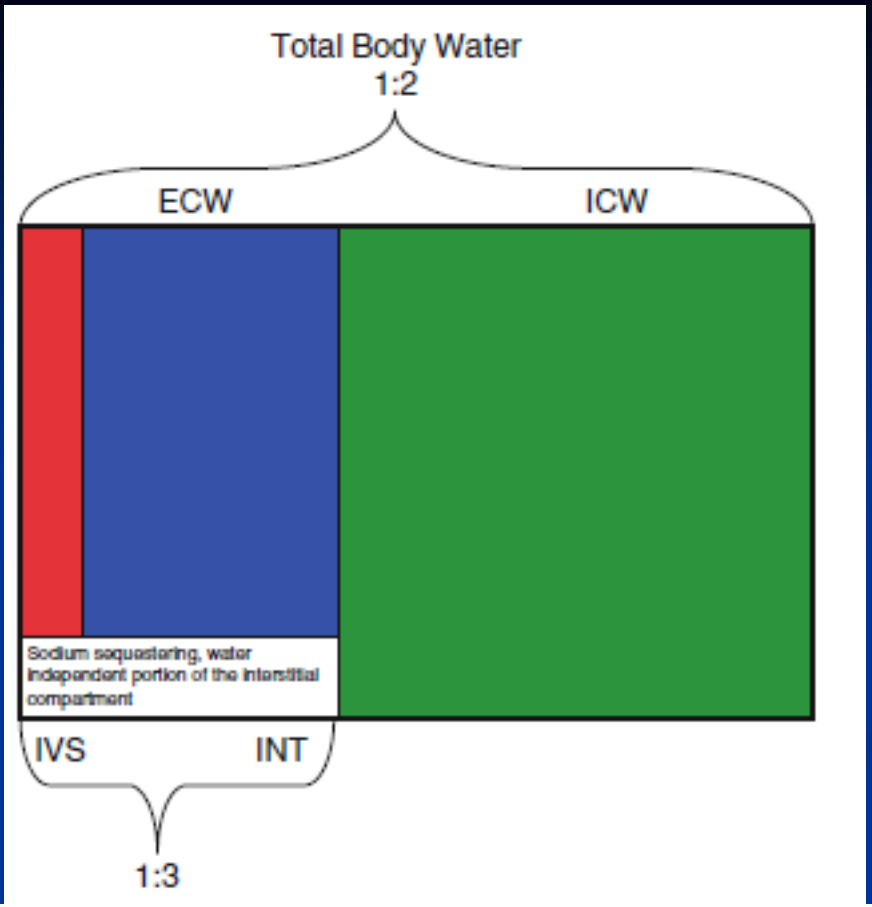


Table 1 Electrolyte (and ion) composition in body fluids (*ECF* extracellular fluid, *ICF* intracellular fluid)

Ion	ECF	Interstitial	ICF
Sodium	135–145 mEq/l	145 mEq/l	10–20 mEq/l
Potassium	3.5–5.5 mEq/l	3.5–5.5 mEq/l	130–150 mEq/l
Chloride	95–105 mEq/l	100–115 mEq/l	<3 mEq/l
Bicarbonate	22–30 mEq/l	25–35 mEq/l	<10 mEq/l
Phosphate	2 mEq/l	2 mEq/l	110–120 mEq/l
Other	Albumin (plasma space)	No albumin	No albumin

- Effective circulatory volume : sustain perfusion,doest correlate with ECF
- Nephrotic,liver disease :TBW (interstitial) high,decreased ECV
- Tachycardia and delayed cap refill precede signs of ineffective circulation as hypotension,oligurea

Regulatory mechansim

- Glomerular hypoperfusion: < Na to macula densa. ⬆ Renin and aldosterone ⬆ salt reabsorption

- Osmoreceptors in hypothalamus : ⬆ADH and thirst

maintenance

- Daily maintenance estimated and based on energy expenditure 1 ml/kg= 1 Kcal of energy expenditure

For each of the first 10 kg of body weight:	100 ml/kg/day or 4 ml/kg/hr
+ For each of the second 10 kg of body weight:	50 ml/kg/day or 2 ml/kg/hr
+ For every subsequent kg of body weight:	25 ml/kg/day or 1 ml/kg/hr

Columns **1-5** below show the actual quantities for various sizes of patient

Maintenance fluids

- Maintenance =insensible water (ISW) + urine output (UOP)
- ISW : evaporative losses from skin and respiratory,unmeasured
- UOP: 2/3 maintenance,
- measured

Insensible water loss

- This is very variable and impossible to measure.

A starting figure is

25 ml/kg/day for newborns,
20 ml/kg/day for 10 kg baby
15 ml/kg/day for 20-30 kg child
10 ml/kg/day for adults

or 400 ml/m^2/day.

Table 13-3

Factors affecting insensible water losses

Increased losses	% Change	Decreased losses	% Change
Prematurity	100–300	Enclosed incubator	25–50
Radiant warmer	50–100	Humidified air	15–30
Phototherapy	25–50	Sedation	5–25
Hyperventilation	20–30	Decreased activity	5–25
Increased activity	5–25	Hypothermia	5–15
Hyperthermia	12%/°C		

1. Daily water requirement = 100 ml/kg for a child weighing less than 10 kg + 50 ml/kg for each additional kg up to 20 kg + 20 ml/kg for each kg in excess of 20 kg

   The second method is based on BSA and utilizes the following formula:

2. Daily water requirement = 1500 ml/m^2 BSA

   The last method is a refinement of the second and utilizes the following formula:

3. Daily water requirement = Urine output + insensible water losses

Maintenanace

- Maint: to prevent dehydration, elect imbalance, prevent ketoacidosis, protein degradation
- Daily Na req: 2-3 mmol/kg
- Daily K req: 1-2 mmol/100 ml. We should check urine output

Glucose 5% saline .45 %: contain 75 mmol/ 1 l

In small infants G 5%.18 % may be used: contain 30 mmol/l (a 5 kg child will have 500 ml with 15 mmol)

Maintenance lack proteins,fat : need enteral feeds /TPN

- A child weighs 7 kg
- Maintenace 700 ml
- So a child with a weight of 15 Kg has a maintenance of : 100 x 10=1000 , 5*50=250
- Total = 1250 ml
- If a child weighs 25 Kg
- maint= 1000 + (10*50) 500+ (5*20=100)= 1600
- Maximum 2.5 L

Causes of dehydration

- 1.losses : vomiting, diarrhea, third spacing as in burns, bleeding

- 2. renal losses :polyuria as in osmotic diuresis,DKA,post obstructive diuresis,diabetes insipidus

Types of dehydration

- Types :
- according to sodium level
- 1.isotonic
- 2.hypotonic/hyponatremic :Na< 130 mmol/l
- 3.Hypertonic /Hypernatremic : Na > 150 mmol/l

Degree of dehydration

- mild :no signs,only symptoms ,< 5 %
- Moderate dehydration: 5-10 %
- Severe dehydration : > 10%

Assessment of dehydrayion

- Assess dehydration : **history** of losses, intake and feeding, thirst, urine output, activity of child, lethargy

- **Exam**: HR, RR (increased from metabolic acidosis,LA in gastroenteritis),postural hypotension. Hypotension seen in severe dehydration

- Capillary refill, sunken eyes, tented skin,crying with tears, weight loss, lethargy, dryness mucus membranes, sunken fontanelle

Table 13-6

Clinical assessment of dehydration

	Degree of dehydration		
	Mild	Moderate	Severe
Vital signs			
Pulse	Normal	Rapid	Rapid and weak
Blood pressure	Normal	Normal to slightly low	Shock
Weight loss			
Infant	<5%	10%	>15%
Older child	<3%	6%	>9%
Mucous membranes	Tacky	Dry	Parched
Skin turgor	Slightly decreased	Decreased	Tenting
Eye appearance	Normal tearing	Decreased tearing ± sunken	No tears + very sunken
Capillary refill	Normal	Delayed (>3 s)	Very delayed (>5 s)
Urine output	Decreased	Minimal	Anuric

Volume depletion in dehydration

- Repletion : replaces ongoing losses ,deficit
- maintenance :
- Emergent repletion phase: in severe hypovolumeia with delayed capillary refill
- Management by rapid restoration of IVS by 20 ml/kg normal saline bolus over 20 min and then reassessment up to three boluses up to 60 ml/kg
- Route intravenous /intraosseous

Volume repletion

- After saline boluses fluid is initiated according to deficit
- Deficit= weight x 10 x % of dehydration
- Oral rehydration solution can be used in children with mild to moderate dehydration, but intravenous route is needed if the child was oral intolerant and has moderate dehydration and in children with severe dehyration

Oral Rehydration solution (ORS)

- Used in children with mild to moderate dehydration
- Has decreased mortality and morbidity from gastroenteritis in developed countries
- Uses glucose in formulation to facilitate sodium absorption through Na-Glucose channel
- There are many formulations: WHO with high Na content,newer has lower sodium

Intravenous Fluid contents

Each 1 l NS .9% HAS 154 mmol Na

Each ONE ML HTS 2.7%= .45 mmol Na

Each 1l GS.45% has 75 mmol Na

Each 1l GS.3% has 50 mmol Na

Each 1l GS.18% has 30 mmol Na

- A child weighs 17 kg,presents to E/R with vomiting and diarrhea.On exam he wasn't dehydrated.He is intolerant to oral intake.Calculate fluid?
- maint: 1000 + (7*50)=1350
- Degree of dehydration mild,deficit= 5%*17*10=850
- Total fluid=850+1350=2200 ml GS 0.45% we divide half over first 8 hours and the remaining over 16 hours

Isotonic dehydration management

- A child presents with gastroenteritis.On exam he was tachycardiac.Serum Na was 140, his weight 20 kg.How to calculate fluid?
- maint= 1500 ml
- Deficit= 20 x10 x 7%= 1400
- Total=2900 G5 .45 %, we divide half over first 8 hours and the remaining over 16 hours.

- A 6 month old boy presents with excessive vomiting,lethargy and diarrahe.On exam capillary refill 5 seconds,Bp un recordable,weight 7 kg?
- What is your next step of management
- 1.give normal saline bolus 140 ml and reassess
- 2.maint=700 ml,deficit 7*10%*10=700
- Total 1400 over 24 hours

You were called to write the fluids of a 1 year old boy,who has not passed urine,his weight is 12 Kg?

insensible losses as 400 ml/m2 and replacement of urine output?

hyponatremia

- Factitious Hyponatremia in DKA.
- Causes:
- 1. loss of sodium in excess to water
- 2.Gain of water in excess of sodium

Decreased ECF,loss of salt in excess of water

- 1.extrarenal losses as GIT losses,skin losses as CF,third space losses .Una < 20,high urine osmolality

- Renal losses as osmotic diuresis,diuretics,adrenal deficiency (hypoaldosteronsim) ,salt losing CRF , Una > 20

Normal ECF,gain of water in excess of salt

- Non edematous state as
- SIADH
- Psychogenic polydipsia,compulsive water drinking have dilute urine
- Hypothroidism
- Una > 20
- Treatment :fluid restriction

ECF increased as gain of water in excess of salt

- Edematous state as nephrotic syndrome,CHF,liver failure.Una< 20,high urine osmolality

- Renal failure as ARF,CRF .Una > 20.
- Treatment: diuretic and fluid and sodium restriction

Etiology of hyponatremia

Circulating volume	Urinary Na (mEq/L)	
	≤ 20	≥ 20
Decreased	Burns	Adrenal insufficiency
	Cystic fibrosis	Diuretics –early
	Diuretics – late	Salt wasting
	Gastroenteritis	
Normal or Increased	Cardiac failure	Renal failure
	Hepatic cirrhosis	SIADH
	Nephrotic syndrome	Water intoxication

Hyponatremic dehydration

Symptoms:acutely seizures due to brain swelling,edema treated wuth hypertonic saline

Nausea,malaise,lethargy

- Signs and symptoms are more evident
- Hyponatremic : shift of fluid to ICS,cerebral edema
- Correct hyponatremia by 10-12 mmol/day to avoid central pontine myelinolysis
- If symptomtic hyponatremia as seizures : use HTS 3% (1 ml contains .45 mmol)
- Use formula for mmol: (desired-actual) x weight o .6

hypernatremia

- 1.loss of water in excess of salt,decreased ECW
- Children are irritable,doughy skin
- Have cerebral thrombosis and intracranial hemorrhage
- Hypocalcemia and hyperglycemia
- Renal vein thrombosis is another complication

loss of water in excess of salt and low ECW

- A. extrarenal loss (urine osmo high,Una < 20) in diarrhae and inadequate water intake

- B.Renal losses
- Central and nephrogenic DI
- hyperglycemia, diuretics, intrinsic renal disease

Gain of salt in excess of water

- Have high urine Na
- Excessive oral ingestion
- Excess Minerlacorticoid
- Excessive intravenous saline
- Rapid correction by using diuertics,dialysis

Hypernatremic dehydration

- Avoid use of hypotonic solutions. use GS .3% - GS .45%
- Start at a rate of 1.25- 1.5 maintaince over 24 hours
- Correct hypernatremia over 48-72 hours
- Adjust rate of drop by altering rate of fluids and concentration
- If drop too quickly : decrease rate of fluids or increase saline concentration

What other labs need to be done in a child with dehydration ?

- 1.elecrolytes
- 2. capillary blood gas : gastroenteritis causes metabolic acidosis from diarrhaea losses and dehydration cause lactic acidosis
- Dehydrated children are tachypnea
- The acidosis will be corrected by hydration
- 3. Hypokalemia : use 3- 4 mmol/100 ml

- 4. urea and creat: prerenal azotemia is seen,oliguria
- 5. urine specific gravity ,osmolarity
- Uirne sodium :low

- A child presents with gastroenteritis and severe dehydration. Weight was 10 kg,Na was 125
- Total fluid :1000 +1000= 2000L GS.45%
- Sodium =10*.6 *10 = 60 mmol
- 2 l has 150 mmol


THANK YOU

SIADH

- Result from CNS,pulmonary disorders,cancer,drugs
- Have low blood osmolality
- Urine osmolality is in appropriately high
- Urine Na is high,serum uric acid is low
- condition of exclusion – must have no dehydration, no pituitary, adrenal, renal or liver disease. Not on diuretics or some other drugs. Not hypothyroid
- Treatment by fluid restriction

Table 13-4

Common causes of vasopressin effect in hospitalized children

Category	Specific etiology
Physiologic	Hyperosmolar state, hypovolemia
Pulmonary	Pneumonitis, pneumothorax, asthma, bronchiolitis, cystic fibrosis
Drug effect	Narcotics, barbiturates, carbamazepine, vincristine, cyclophosphamide
Metabolic	Hypothyroidism, hypoadrenalism, porphyria
CNS	Infection (meningitis or encephalitis), tumor, trauma, hypoxia, shunt malfunction, nausea, pain, anxiety

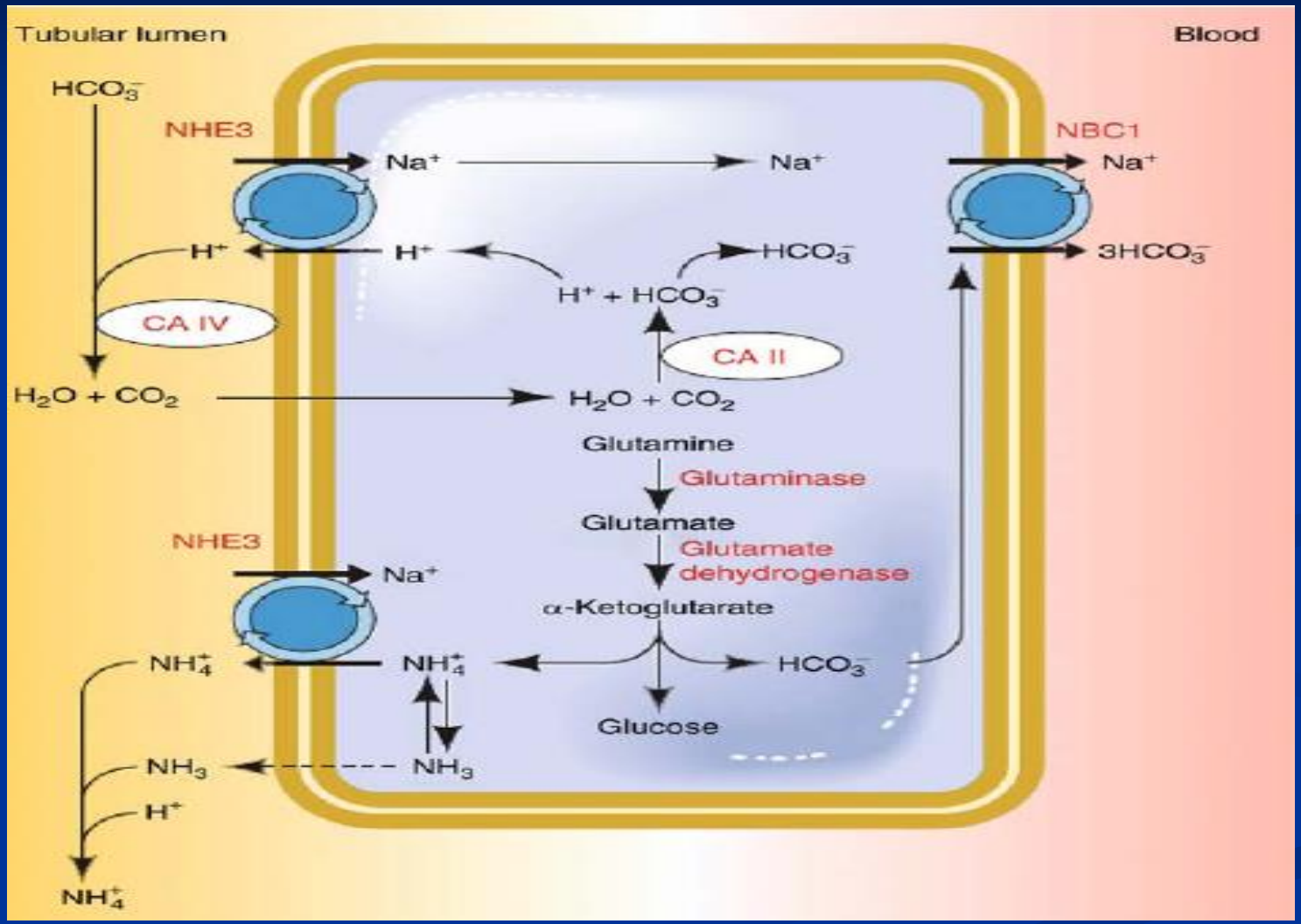
Acid base disorders

- Normal ph: 7.35 -7.45
- Pco2 :35-45
- HCO3 : 20-28
- 1. know of academia or alkalemia
- 2.know if metabolic or respiratory
- 3.know compensatory response

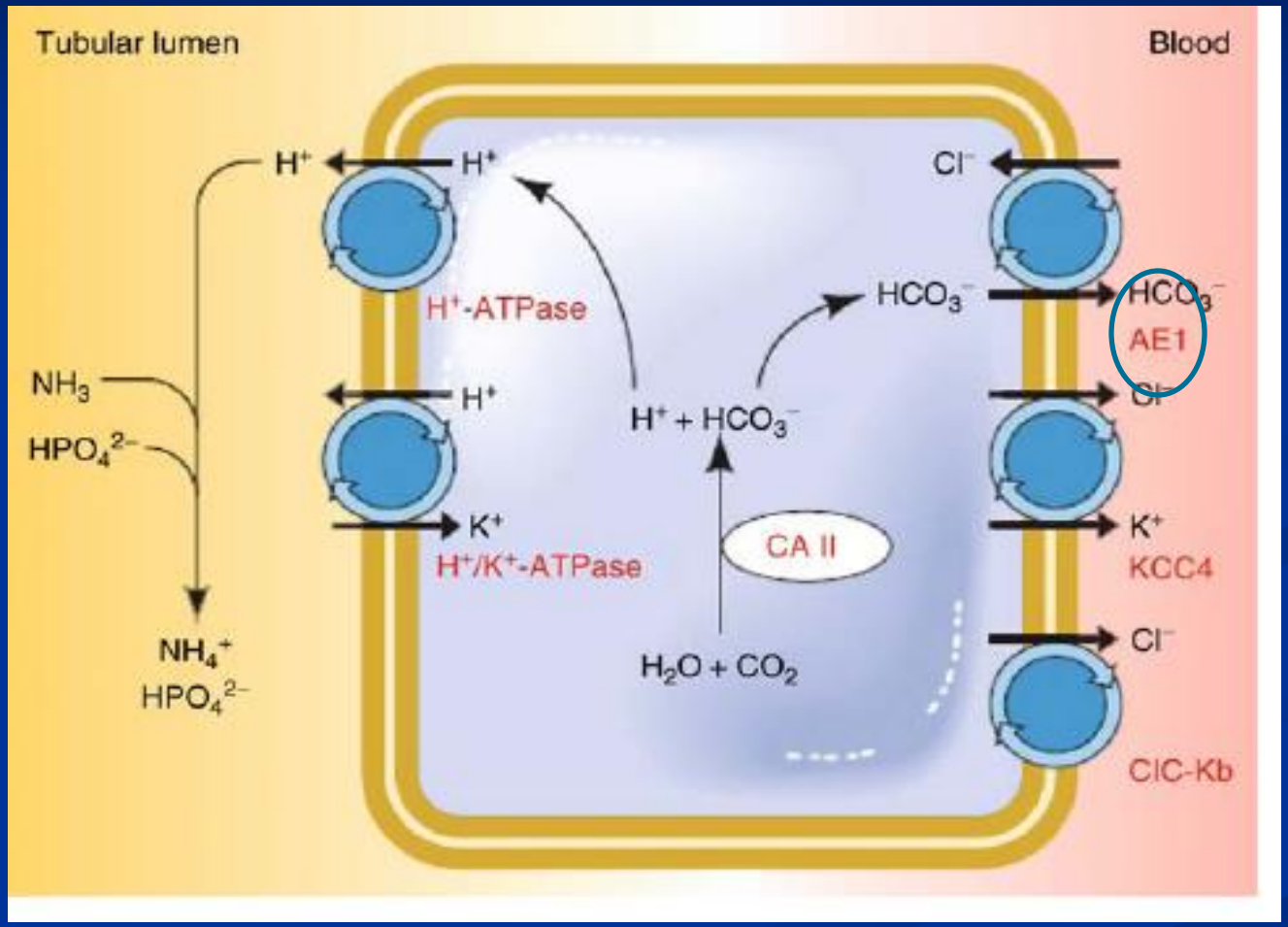
Causes of metabolic acidosis

- 1. increased endogenus /exogenous acid production
- 2. increase biocarbonate losses
- 3.decrease acid excretion

Proximal tubule



Distal tubule



Metabolic acidosis

Anion gap=(Na) –(CL + bicarbonate)

Normal up to 14-16

1.high anion gap acidosis

- Endogenous sources of acid (DM,organic acidemia,lactic acidosis
- Exogenous acids:ethylene glycol
- Defective acid excretion: uremic acidosis

Normal anion gap metabolic acidosis

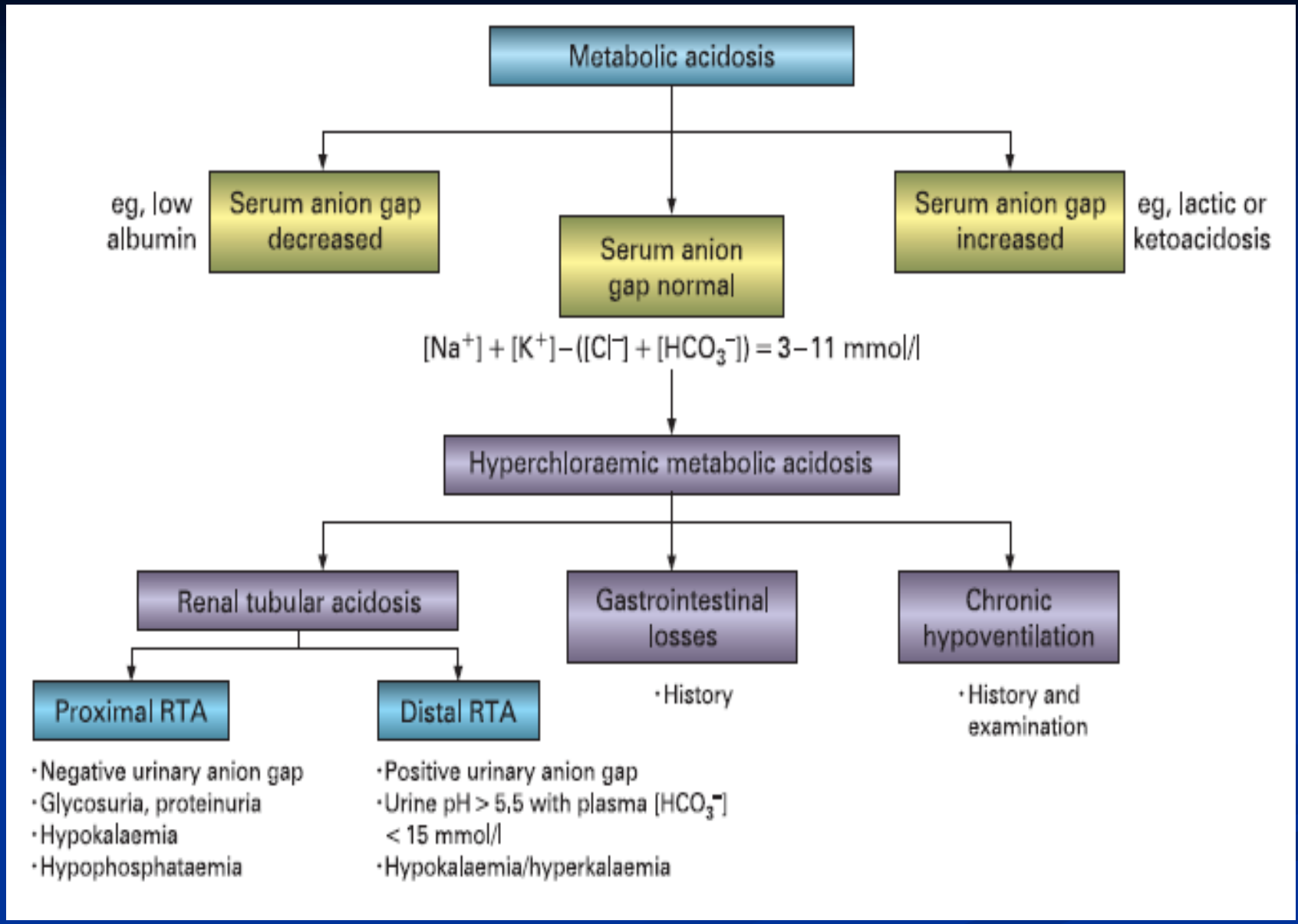
- Extrarenal :diarrhael disease
- Renal RTA : proximal RTA ,distal RTA
- Type 4 RTA :hyperkalemia; transient in UTI,urinary obstruction

Proximal RTA

- Decrease reabsorptive capacity
- Require huge doses of HCO3
- Isolated or part of Fanconi with hypophosphatemia,glucosuria,aminoaciduria
- high HCO3 losses, obligate Na, k losses,volume depletion,increase aldoest…hypokalemia
- urine ph < 5.5 ,

Distal RTA

- Defect acidification mechanism
- Can not acidify urine below 5.5
- Require 1-3 mmol/kg
- Nephrocalcinosis,hypocitraturia,hypercalcurea
- Etiology: congenital +,- deafness,acquired
- Positive urine anion gap (Na+ K-CL) negative


Metabolic acidosis
eg, low albumin
Serum anion gap decreased
Serum anion gap normal
Serum anion gap increased
eg, lactic or ketoacidosis
$[Na^+] + [K^+] - ([Cl^-] + [HCO_3^-]) = 3-11$ mmol/l
Hyperchloraemic metabolic acidosis
Renal tubular acidosis
Gastrointestinal losses
Chronic hypoventilation
Proximal RTA
Distal RTA
·History
·History and examination
·Negative urinary anion gap
·Glycosuria, proteinuria
·Hypokalaemia
·Hypophosphataemia
·Positive urinary anion gap
·Urine pH > 5,5 with plasma $[HCO_3^-]$ < 15 mmol/l
·Hypokalaemia/hyperkalaemia

A seven year old boy was noted to have excessive thirst and polyuria. He was admitted in a semi-conscious state, with dehydration.

Na 147 mmol/L	(135 – 145)
K 5.7 mmol/L	(3.7 – 5.4)
Cl 98 mmol/L	(98 – 110)
pH 7.15	(7.34 – 7.43)
pCO_2 23 mm Hg	(32 – 45)
Actual HCO_3 7.0 mmol/L	(18.0 – 25.0)
Base Excess -19.7 mmol/L	(-4 - +3)
Urea 70 mg/dl	(15-45)

Metabolic alkalosis

- Chloride responsive hypokalemic hypochloremic metabolic alkalosis :
- Loss of acid from stomach: vomiting,nasogastric suction
- Congenital Chloride diarrhoea
- Cystic fibrosis
- Urine CL < 10 mmol

Chloride resistant metabolic alkalosis

- Normal BP : Bartter, gitelman
- High BP : renal artery stenosis, Primary hyperaldosteronism,Liddle syndrome

- Urine Cl > 20 , volume replete

Decreased ECF,loss of salt in excess of water

- 1.extrarenal losses as GIT losses,skin losses as CF,third space losses .Una < 20,high urine osmolality

- Renal losses as osmotic diuresis, diuretics,cerebral salt wasting,adrenal def ,salt losing CRF , Una > 20