DR S NARESH KUMAR

ASSOCIATE CONSULTANT- PEDIATRIC NEPHROLOGY

RAINBOW CHILDREN'S HOSPITAL, CHENNAI

CASE :

A 6-year-old boy presents with poor growth, muscle weakness, and frequent urination. His parents report delayed walking and bowing of the legs.

HISTORY

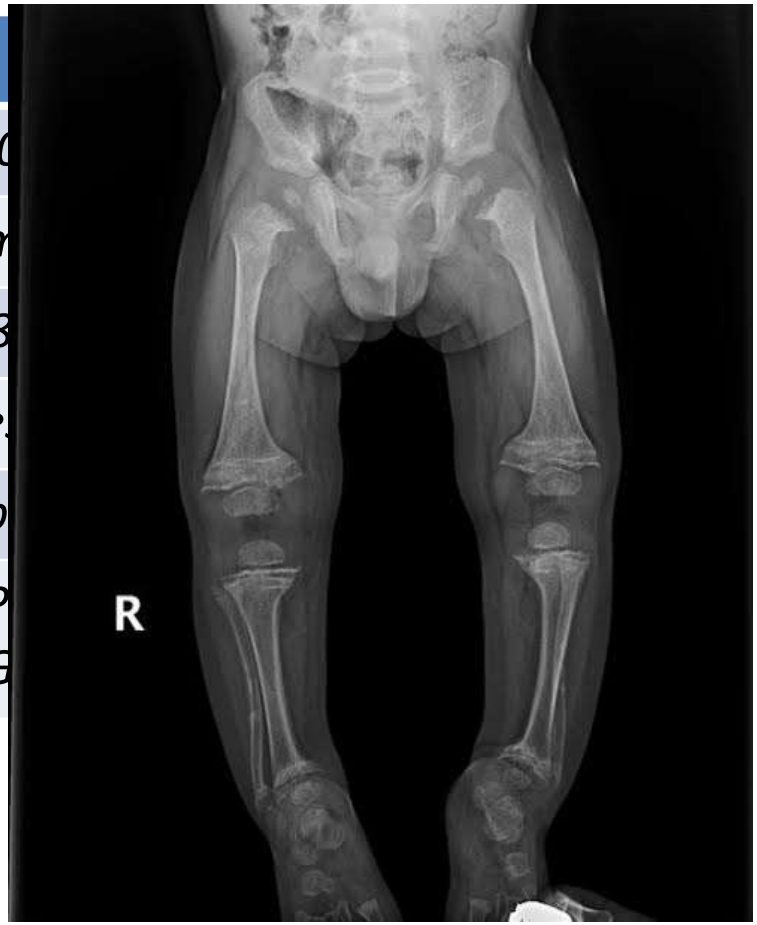
- *Failure to gain weight*
- *Muscle weakness*
- *Polyuria*
- *Bony abnormalities*

EXAMINATION

- *Failure to thrive*
- *Hypotonia*
- *Mild dehydration with normal blood pressure*
- *Frontal bossing,Wrist widening,Rachitic Rosary, Harrison sulcus, Genu Varum*
- *Tachypneic*
- *Protruberant abdomen*

ABG	
pH: 7.30	Urea 2(
HCO_3^-: 14	Calcium
pCO2 30	ALP: 48
Na: 138	Magne
K: 3	Urine p
Cl: 112	Urine P Urine G

Anionic Gap
(138)-
(112+14)
*= **12***



X-ray Bilateral knee joint

USG ABDOMEN : Normal

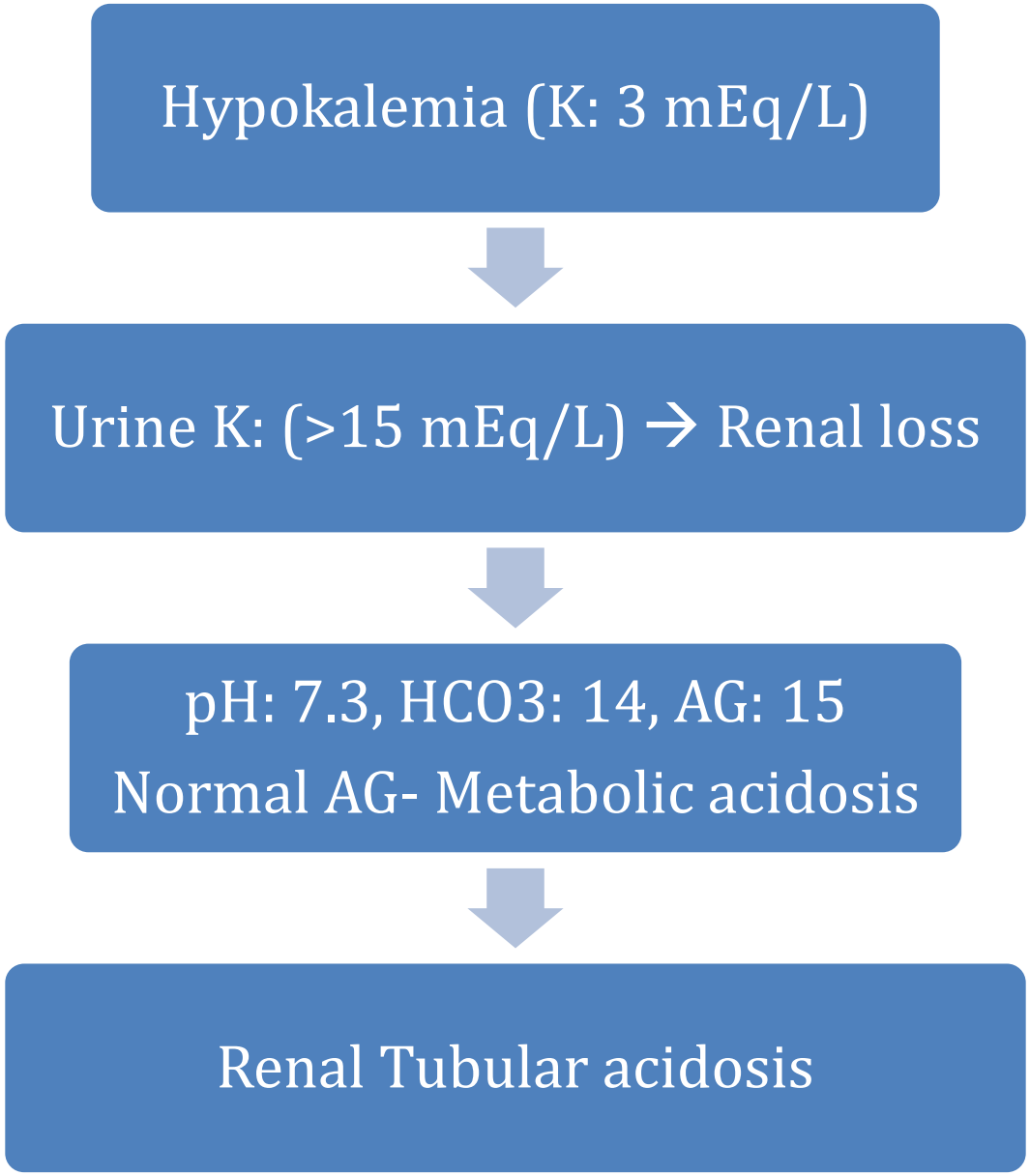

Hypokalemia (K: 3 mEq/L)
Urine K: (>15 mEq/L) → Renal loss
pH: 7.3, HCO3: 14, AG: 15
Normal AG- Metabolic acidosis
Renal Tubular acidosis

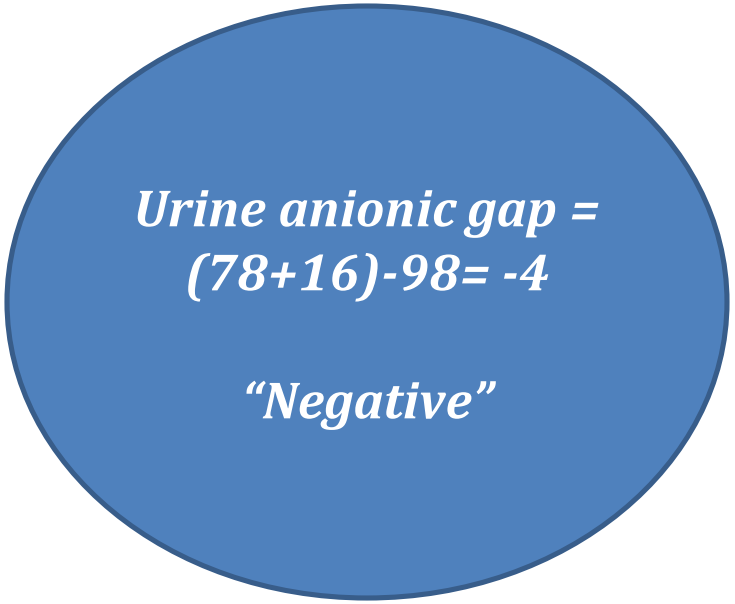
Table 1 Summary of renal tubular acidosis classification, diagnostic characteristics, and treatment options

	Distal (type 1) RTA	**Proximal (type 2) RTA**	**Hyperkalemic (type 4) RTA**
Primary defect	Decreased distal acid excretion or increased H^+ membrane permeability	Decreased proximal reabsorption of HCO_3^-	Reduced excretion of acid and K^+ in the collecting duct
Symptoms	Polydipsia, polyuria, muscle weakness, nephrolithiasis, nephrocalcinosis, growth retardation or failure to thrive, rickets	Muscle weakness or paralysis (if severely hypokalemic), growth retardation in early childhood	Often asymptomatic, occasional muscle weakness of cardiac arrhythmia
Urine pH	> 5.3	< 5.5	< 5.5

-Palmer BF et al Renal tubular acidosis and management strategies: a narrative review. Adv Ther. 2020

1) What further investigations are needed?

- *Urinary spot sodium, potassium, Chloride →*
  Calculate ***urine anionic gap***



- *Calculate Fractional excretion of Phosphorous*

$$\textbf{FePO4} = \frac{\text{24 hours Urinary Phosphorous}}{\text{Serum Phosphorous}} \times \frac{\text{Serum creatinine}}{\text{24 hours Urinary creatinine}} \times 100$$

- *Calculate Tubular Reabsorption of Phosphorous*

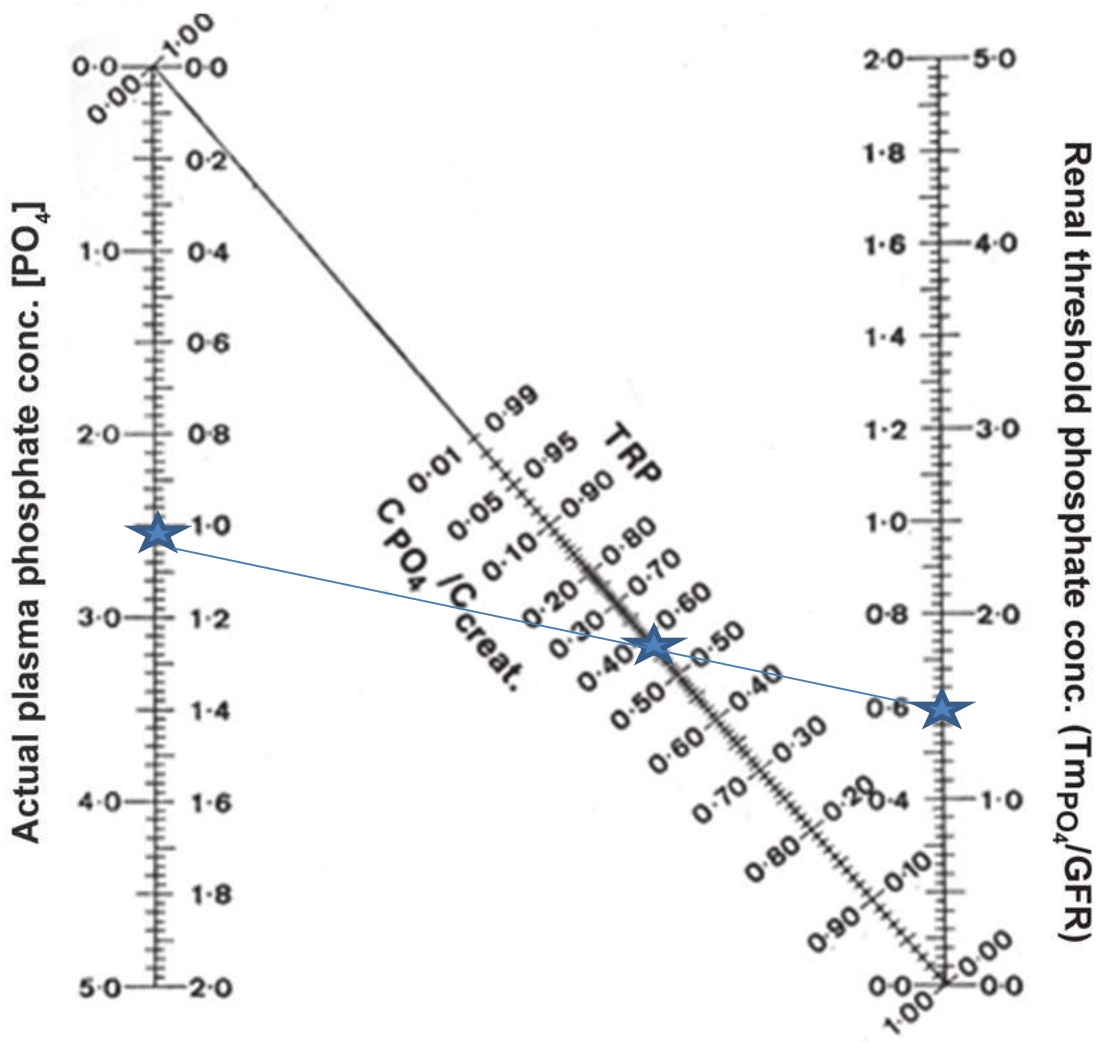
$$\textbf{(TRP} = \frac{\text{1- FePO4)}}{100}$$

- *24 hour Urinary Phosphorous – 348 mg*
- *24 hour Urinary Creatinine – 94 mg*
- *Serum Phosphorous – 2.5 mg/dl*
- *Serum Creatinine – 0.3 mg/dl*

- *FePO4 = 44%*
- *TRP = 1-0.44 = 0.56*

To estimate TMP/GFR
(Tubular maxiumum reabsorption of phosphate per glomerular filtration rate)

WALTON-BIJVOET NOMOGRAM



Nomogram for derivation of renal threshold phosphate concentration.

- *TMP/GFR = 1.5 (< 2.8) is suggestive of* ***Phosphaturia***

Normal TMP/GFR= 2.8 -4.4 mg/dl

2) What is the most likely diagnosis ?

Proximal Renal Tubular Acidosis

4) What is the treatment approach for this condition?

Correct the volume status if underhydrated.

Supplementation of

- *High doses of bicarbonate (10-15mEq/Kg/day)*
- *Potassium (1-5 mEq/kg/day)*
- *Phosphate (20-40 mg/kg/day)*
- *Sodium (3-5 mEq/kg/day)*
- *Magnesium (25-50 mg/kg/day)*

Correct magnesium before or concurrenty with potassium

15ml = 1000 mg = 12 mEq sodium and 12 mEq bicarbonate

5ml = 10 mEq potassium and 10 mEq citrate

1 sach = 500 mg elemental phosphorous

400 mg magnesium oxide = 240 mg elemental magnesium

15 ml Kcl = 20 mEq potassium

1 gm sodium chloride contains 17 mEq sodium

CASE :

A 4-year-old boy is brought to the clinic due to poor growth, muscle cramps, and excessive thirst. His mother reports that he urinates frequently and often wakes at night to drink water. He also has a craving for salty food. On examination, he has normal blood pressure and mildly dehydrated.

HISTORY

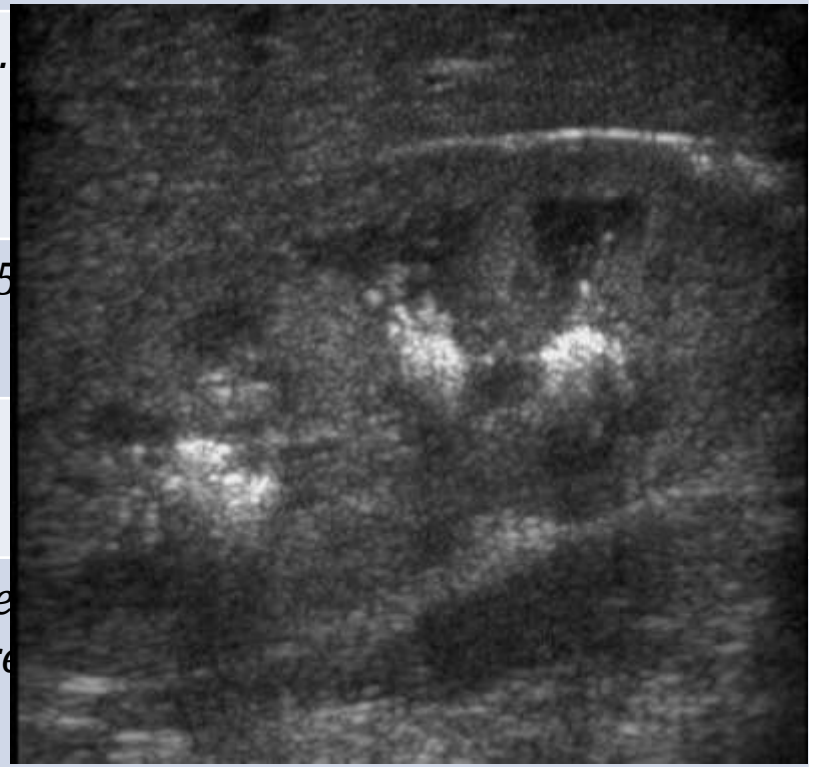
- *Failure to gain weight*
- *Muscle cramps*
- *Polyuria and polydypsia*
- *Salt craving*

- *Antenatal history of polyhydramnios and premature birth*

EXAMINATION

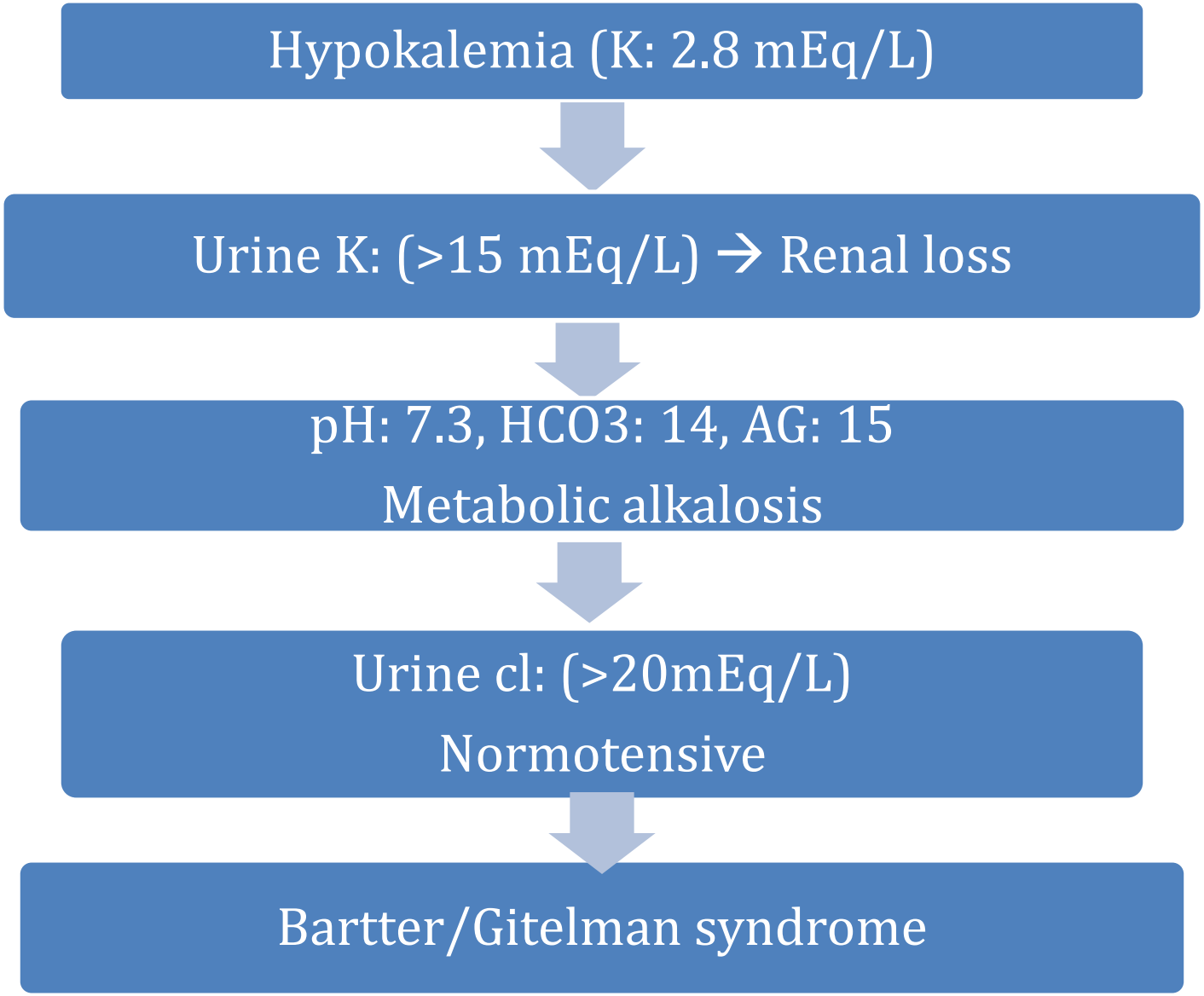
- *Failure to thrive*
- *Mild dehydration*
- *Reduced muscle tone*
- *Blood pressure - Normal*

ABG	LABS
pH 7.48	*Urea 20, Creat: 0.3*
HCO_3^- 30	*Calcium: 9.*
pCO2: 48	*Urine pH: 5*
Na: 1	*Urinalysis:*
K:	*Urinary ele calcium-cre*
Cl: 92	***USG**: Bilateral medullary nephrocalcinosis*

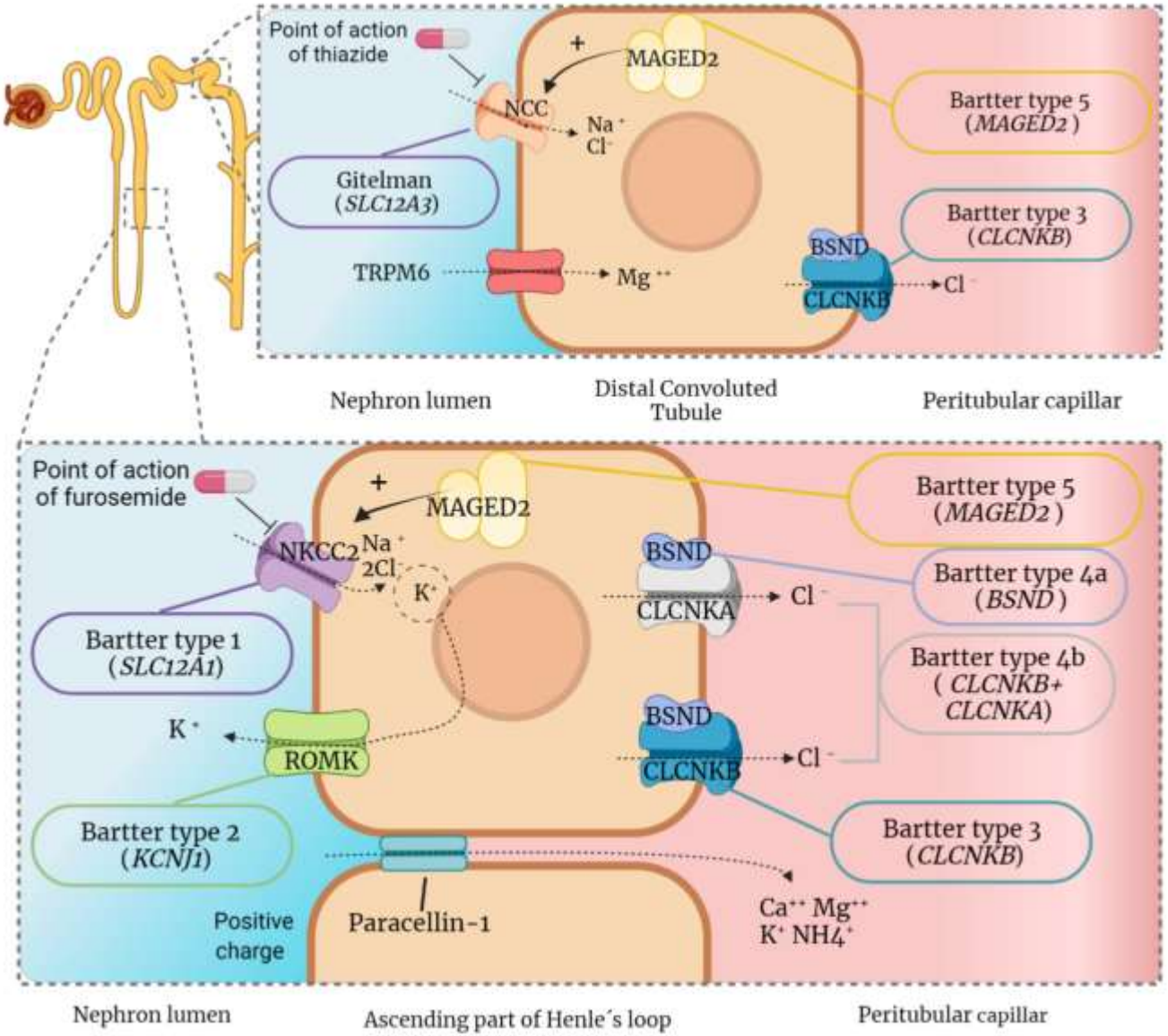


Metabolic alkalosis with hyponatremia, hypokalemia and hypochloremia

Hypercalciuria with bilateral medullary nephrocalcinosis


Hypokalemia (K: 2.8 mEq/L)
Urine K: (>15 mEq/L) → Renal loss
pH: 7.3, HCO3: 14, AG: 15
Metabolic alkalosis
Urine cl: (>20mEq/L)
Normotensive
Bartter/Gitelman syndrome

Bartter's syndrome



BARTTER VS GITELMAN SYNDROME

BARTTER	*GITELMAN*
➢ *Early age at onset/**early childhood***	➢ *Later onset/**Late childhood***
➢ *Polyhydramnios – in neonatal bartter (Type 1 and 2), rarely in classical (Type 3) bartter*	➢ *Not usually seen*
➢ *Tetany rare*	➢ ***Tetany present***
➢ *Urine calcium excretion – High (**Hypercalciuria**)*	➢ *Urine calcium excretion – Normal*
➢ ***Urinary prostaglandins (PGE2) high***	➢ *Urinary prostaglandins (PGE2)- Normal*
➢ *Serum magnesium occasionally low*	➢ ***Serum magnesium low***
➢ ***Nephrocalcinosis** in ultrasound*	➢ *Normal ultrasound*

2) What is the treatment approach for this condition?

- *Correct volume status with dehydration correc*
- *Sodium chloride supplementation (5-10 mEq*
- *Potassium Chloride (K: 1-5 mEq/kg/day)*
- *Magnesium (25-50 mg/kg/day)*
- *NSAID's*

Target K : 3 mmol/L

Indomethacin (1-4mg/kg/day in 3-4 divided doses)

Ibuprofen (15-30 mg/kg/day in 3 doses)

Celecoxib (2-10 mg/kg/day in 2 doses)

3) What are the differential diagnosis ?

Table 4 | Differential diagnosis of Bartter syndrome

Leading symptom	Differential diagnosis	Additional findings
Polyhydramnios of fetal origin	Aneuploidia	Abnormal karyotype
	Gastrointestinal tract malformation	Variable, empty stomach
	Congenital chloride diarrhea	Dilated intestinal loops
Salt loss	Pseudohypoaldosteronism type I	Metabolic acidosis, hyperkalemia
Salt loss with hypokalemic alkalosis	Congenital chloride diarrhea	Low urinary chloride
	Pseudo-Bartter syndrome, e.g., in CF	Low urinary chloride
	Gitelman syndrome	Hypocalciuria, hypomagnesemia
	HNF1B nephropathy	Renal malformation, cysts, MODY5, hypomagnesemia
	HELIX syndrome	Hypercalcemia, hypohidrosis, ichthyosis
	Autosomal dominant hypocalcemia	Hypocalcemia, seizures
	EAST/SeSAME syndrome	Ataxia, seizures, deafness, developmental delay
	Surreptitious vomiting	Low urinary chloride
	Surreptitious laxative use	Low urinary chloride
	Surreptitious diuretic use	Highly variable urinary chloride
Hypokalemic alkalosis without salt loss	Primary hyperaldosteronism;	Hypertension, low renin
	Apparent mineralocorticoid excess	Hypertension, low renin/ aldosterone
	Liddle syndrome	Hypertension, low renin/ aldosterone
Nephrocalcinosis	Distal renal tubular acidosis	Metabolic acidosis
	Proximal tubular defects	No metabolic alkalosis
	Familial hypomagnesemia/ hypercalciuria	No hypokalemic metabolic alkalosis, CKD
	Apparent mineralocorticoid excess	Hypertension, low renin/ aldosterone

CF, cystic fibrosis; CKD, chronic kidney disease; EAST, epilepsy, ataxia, sensorineural deafness, tubulopathy; HELIX, hypohidrosis, electrolyte imbalance, lacrimal gland dysfunction, ichthyosis, xerostomia; HNF1B, hepatocyte nuclear factor 1 beta; MODY5, maturity onset diabetes of the young type 5; SeSAME, seizures, sensorineural deafness, ataxia, mental retardation, electrolyte imbalance.

Additional readings

- Rodríguez Soriano J. Renal tubular acidosis: the clinical entity. J Am Soc Nephrol. 2002 Aug;13(8):2160-70.

- Bagga A, Bajpai A, Menon S. Approach to renal tubular disorders. Indian J Pediatr. 2005 Sep;72(9):771-6.

- Palmer BF, Kelepouris E, Clegg DJ. Renal tubular acidosis and management strategies: a narrative review. Adv Ther. 2020;38(2):949-968.

- Renal Tubular Acidosis: Core Curriculum 2025 Bonner, Ryan et al. American Journal of Kidney Diseases, Volume 85, Issue 4, 501 – 512

- Diagnosis and management of Bartter syndrome: executive summary of the consensus and recommendations from the European Rare Kidney Disease Reference Network Working Group for Tubular Disorders. Konrad, Martin et al. Kidney International, Volume 99, Issue 2, 324 - 335

THANK YOU