CASE SCENARIOS

Metabolic Acidosis

DR. SUKANYA GOVINDAN

M.D(PED), D.M (NEPH), FISN

Senior consultant, Pediatric Nephrology

Mehta Multispeciality Hospitals, Chennai

NEPHKIDS 2020

Case 1

A male baby born to primi mother with birth wt of 4.0 kg was brought on D15 of life with poor feeding and lethargy for one day. The baby is on EBF and there is no history of diarrhea. No wet diapers for last 14 hours. Examination- irritable and lethargic and has severe dehydration. His current wt is 2. 5 kg , loss of 37%. HR was 160/min with feeble pulses. Tests including ABG is as below:

pH 7.29, pCo2 28.5, HCo3 – 13.5, Na – 185, K – 5.95, Cl –144, HCO3 –13.5
Serum creatinine – 2.5 mg/dl, serum urea 216 mg/dl

contd....

pH 7.29, pCo2 28.5, HCo3 13.5, Na 185, K 5.95, Cl 144, HCO3 13.5

Normal values :

pH: 7.35 - 7.45

HCo3 : 22-24 (24)

pCO2 : 40

AG : 10 –12 (10)

contd….

pH 7.29, pCo2 28.5, HCo3 13.5, Na 185, K 5.95, Cl 144, HCO3 13.5

STEP 1 - pH

contd….

pH 7.29, pCo2 28.5, HCo3 13.5, Na 185, K 5.95, Cl 144, HCO3 13.5

STEP 1 - pH

Acidemia

contd….

pH 7.29, pCo2 28.5, HCo3 13.5, Na 185, K 5.95, Cl 144, HCO3 13.5

STEP 1 - pH

Acidemia

STEP 2 – Direction of pH and pCo2

contd….

pH 7.29, pCo2 28.5, HCo3 13.5, Na 185, K 5.95, Cl 144, HCO3 13.5

STEP 1 - pH

Acidemia

STEP 2 – Direction of pH and pCo2

Metabolic (same direction)

contd….

pH 7.29, pCo2 28.5, HCo3 13.5, Na 185, K 5.95, Cl 144, HCO3 13.5

STEP 1 - pH

Acidemia

STEP 2 – Direction of pH and pCo2

Metabolic (same direction)

STEP 3 – Compensation (Winter's formula)

contd….

pH 7.29, pCo2 28.5, HCo3 13.5, Na 185, K 5.95, Cl 144, HCO3 13.5

STEP 1 - pH

Acidemia

STEP 2 – Direction of pH and pCo2

Metabolic (same direction)

STEP 3 – Compensation (Winter's formula)

PCo2 = 1.5(13.5)+8 ± 2 = **28 ±2 (26-30)**

contd....

pH 7.29, pCo2 28.5, HCo3 13.5, Na 185, K 5.95, Cl 144, HCO3 13.5

Metabolic acidosis with adequate respiratory compensation

contd....

pH 7.29, pCo2 28.5, HCo3 13.5, Na 185, K 5.95, Cl 144, HCO3 13.5

Metabolic acidosis with adequate respiratory compensation

STEP 4 - ANION GAP

contd....

pH 7.29, pCo2 28.5, HCo3 13.5, Na 185, K 5.95, Cl 144, HCO3 13.5

Metabolic acidosis with adequate respiratory compensation

STEP 4 - ANION GAP

Na - (Cl + Hco3)

contd....

pH 7.29, pCo2 28.5, HCo3 13.5, Na 185, K 5.95, Cl 144, HCO3 13.5

Metabolic acidosis with adequate respiratory compensation

STEP 4 - ANION GAP

Na - (Cl + Hco3)

185 –(144+ 13.5) = **27.5 (high AG)**

contd....

pH 7.29, pCo2 28.5, HCo3 13.5, Na 185, K 5.95, Cl 144, HCO3 13.5

Metabolic acidosis with adequate respiratory compensation

STEP 4 - ANION GAP

Na - (Cl + Hco3)

185 –(144+ 13.5) = **27.5 (high AG)**

STEP 5 – DELTA RATIO

contd....

pH 7.29, pCo2 28.5, HCo3 13.5, Na 185, K 5.95, Cl 144, HCO3 13.5

Metabolic acidosis with adequate respiratory compensation

STEP 4 - ANION GAP

Na - (Cl + Hco3)

185 –(144+ 13.5) = **27.5 (high AG)**

STEP 5 – DELTA RATIO

Δ AG/ΔHCo3

contd....

pH 7.29, pCo2 28.5, HCo3 13.5, Na 185, K 5.95, Cl 144, HCO3 13.5

Metabolic acidosis with respiratory compensation

STEP 4 - ANION GAP

Na - (Cl + Hco3)

185 –(144+ 13.5) = **27.5 (high AG)**

STEP 5 – DELTA RATIO

Δ AG/ΔHCo3 = (27.5-10)/(24-13.5)

18/11 = 1.6

DELTA RATIO

Unit change in Δ AG = Unit change in Δ HCO3

Normal Δ ratio - 1-2 --> Isolated High AG Metabolic Acidosis (HAGMA)

Δ ratio < 1 ---> associated Normal AG Metabolic Acidosis (NAGMA)

Δ ratio > 2 ---> associated Metabolic alkalosis

Our case:

Δ AG/Δ HCo3 = 18/11 = 1.6

Isolated High AG metabolic acidosis

Case analysis

A male baby born to primi mother with birth wt of 4.0 kg was brought on D15 of life with poor feeding and lethargy for one day. The baby is on EBF and there is no history of diarrhea. No wet diapers for last 14 hours. Examination- irritable and lethargic and has moderate dehydration. His current wt is 2. 5 kg , loss of 37%. HR was 160/min with feeble pulses. Serum creatinine – 2.5 mg/dl, serum urea 216 mg/dl

HIGH ANION GAP METABOLIC ACIDOSIS WITH ADEQUATE COMPENSATION

Case analysis

A male baby born to primi mother with **birth wt of 4.0 kg** was brought on D15 of life with **poor feeding** and lethargy for one day. The baby is on EBF and there is no history of diarrhea. **No wet diapers** for last 14 hours. Examination- irritable and lethargic and has **severe dehydration**. His current wt is 2. 5 kg , **loss of 37%**. HR was 160/min with feeble pulses. **Serum creatinine – 2.5 mg/dl, serum urea 216 mg/dl**

HIGH ANION GAP METABOLIC ACIDOSIS WITH ADEQUATE COMPENSATION

Case analysis

Metabolic acidosis

Net gain of acid

- Increased acid production e.g. lactic acidosis, ketoacidosis
- Reduced excretion of inorganic acids e.g. renal failure

Increased bicarbonate loss

- Diarrhea, renal tubular acidosis

Dilution of serum bicarbonate

- Non-balanced fluids - normal saline

High anion gap met acidosis

Net gain of acid

- Is ECF volume low? (dehydrated) - DKA , lactic acidosis
- Is GFR low (high serum creatinine)? – AKI / CKD
- High plasma osmolal gap – methanol, ethylene glycol
- Sepsis / shock – Lactic acidosis

Case analysis

Metabolic acidosis

Net gain of acid

- Increased acid production e.g. lactic acidosis, ketoacidosis
- Reduced excretion of inorganic acids e.g. renal failure

Increased bicarbonate loss

- Diarrhea, renal tubular acidosis

Dilution of serum bicarbonate

- Non-balanced fluids - normal saline

High anion gap met acidosis

Net gain of acid

- Is ECF volume low? **(dehydrated)** - DKA , **lactic acidosis**
- **Is GFR low (high serum creatinine)? – AKI / CKD**
- High plasma osmolal gap – methanol, ethylene glycol
- **Sepsis / shock – Lactic acidosis**

Diagnosis and further management

Hypernatremic dehydration – high anion gap metabolic acidosis

Further evaluation:

- Serum lactate
- Serum and urine osmolality

Treatment:

- Fluid resuscitation – free water correction
- Relatively hypotonic fluids – Normal saline

Case 2

6 month old female infant with failure to thrive presents to your clinic. Mother gives history of increased diaper weights and increased thirst. The child's weight is <3rd centile for age. The kidney ultrasound shows hyperechoic medulla. Blood gas analysis and serum biochemistries are as follows:

pH 7.18, pCo2 - 19 HCo3 – 9.2
Na – 135
K – 5.05
Cl –108
HCO3 – 8.8
Serum creatinine – 0.5 mg/dl, serum albumin 4.0 g/dl

contd….

pH 7.18, pCo2 – 19, HCo3 – 9.2, Na – 135, K – 5.05, Cl –108, HCO3 – 8.8

STEP 1 - pH

contd….

pH 7.18, pCo2 – 19, HCo3 – 9.2, Na – 135, K – 5.05, Cl –108, HCO3 – 8.8

STEP 1 - pH

Acidemia

contd….

pH 7.18, pCo2 – 19, HCo3 – 9.2, Na – 135, K – 5.05, Cl –108, HCO3 – 8.8

STEP 1 - pH

Acidemia

STEP 2 – Direction of pH and pCo2

contd….

pH 7.18, pCo2 – 19, HCo3 – 9.2, Na – 135, K – 5.05, Cl –108, HCO3 – 8.8

STEP 1 - pH

Acidemia

STEP 2 – Direction of pH and pCo2

Metabolic (same direction)

contd….

pH 7.18, pCo2 – 19, HCo3 – 9.2, Na – 135, K – 5.05, Cl –108, HCO3 – 8.8

STEP 1 - pH

Acidemia

STEP 2 – Direction of pH and pCo2

Metabolic (same direction)

STEP 3 – Compensation (Winter's formula)

contd….

pH 7.18, pCo2 – 19, HCo3 – 9.2, Na – 135, K – 5.05, Cl –108, HCO3 – 8.8

STEP 1 - pH

Acidemia

STEP 2 – Direction of pH and pCo2

Metabolic (same direction)

STEP 3 – Compensation (Winter's formula)

PCo2 = 1.5(9)+8 ± 2 = **21.5 ±2 (19.5-23.5)**

contd….

pH 7.18, pCo2 – 19, HCo3 – 9.2, Na – 135, K – 5.05, Cl –108, HCO3 – 8.8

Metabolic acidosis with adequate respiratory compensation

contd....

pH 7.18, pCo2 – 19, HCo3 – 9.2, Na – 135, K – 5.05, Cl –108, HCO3 – 8.8

Metabolic acidosis with adequate respiratory compensation

STEP 4 - ANION GAP

contd....

pH 7.18, pCo2 – 19, HCo3 – 9.2, Na – 135, K – 5.05, Cl –108, HCO3 – 8.8

Metabolic acidosis with adequate respiratory compensation

STEP 4 - ANION GAP

Na - (Cl + Hco3)

contd....

pH 7.18, pCo2 – 19, HCo3 – 9.2, Na – 135, K – 5.05, Cl –108, HCO3 – 8.8

Metabolic acidosis with adequate respiratory compensation

STEP 4 - ANION GAP

Na - (Cl + Hco3)

135 –(108+ 9) =**18 (high AG)**

contd....

pH 7.18, pCo2 – 19, HCo3 – 9.2, Na – 135, K – 5.05, Cl –108, HCO3 – 8.8

Metabolic acidosis with adequate respiratory compensation

STEP 4 - ANION GAP

Na - (Cl + Hco3)

135 –(108+ 9) =**18 (high AG)**

STEP 5 – DELTA RATIO

contd....

pH 7.18, pCo2 – 19, HCo3 – 9.2, Na – 135, K – 5.05, Cl –108, HCO3 – 8.8

Metabolic acidosis with adequate respiratory compensation

STEP 4 - ANION GAP

Na - (Cl + Hco3)

135 –(108+ 9) =**18 (high AG)**

STEP 5 – DELTA RATIO

Δ AG/ΔHCo3

contd....

PH 7.18, pCo2 - HCo3 -Na – 135 K – 5.05 Cl –108 HCO3 – 8.8

Metabolic acidosis with respiratory compensation

STEP 4 - ANION GAP

Na - (Cl + Hco3)

135 –(108+ 9) =**18 (high AG)**

STEP 5 – DELTA RATIO

Δ AG/ΔHCo3 = (18-10)/(24-9)

8/15 = 0.53

DELTA RATIO

Unit change in Δ AG = Unit change in Δ HCO3

Normal Δ ratio - 1-2 --> Isolated High AG Metabolic Acidosis (HAGMA)

Δ ratio < 1 ---> associated Normal AG Metabolic Acidosis (NAGMA)

Δ ratio > 2 ---> associated Metabolic alkalosis

Our case:

Δ AG/Δ HCo3 = 8/15 = 0.53

(ΔHCo3 > Δ AG, acidosis not explained by AG alone)

Associated Normal AG metabolic acidosis

Case analysis

6 month old female infant with failure to thrive presents to your clinic. Mother gives history of increased diaper weights and increased thirst. The child's weight is <3rd centile for age. Systolic BP – 70 mmHg. The kidney ultrasound shows hyperechoic medulla. Serum creatinine 0.5 mg/dl

METABOLIC ACIDOSIS WITH ADEQUATE RESPIRATORY COMPENSATION

HIGH ANION GAP + NORMAL ANION GAP METABOLIC ACIDOSIS

Case analysis

6 month old female infant with **failure to thrive** presents to your clinic.

Mother gives history of **increased diaper weights and increased thirst**.

The child's weight is <3rd centile for age. **Systolic BP – 70 mmHg.** The kidney ultrasound shows **hyperechoic medulla.** Serum creatinine 0.5 mg/dl

METABOLIC ACIDOSIS WITH ADEQUATE RESPIRATORY COMPENSATION

HIGH ANION GAP + NORMAL ANION GAP METABOLIC ACIDOSIS

Case analysis

High anion gap met acidosis

Net gain of acid

- Is ECF volume low? (dehydrated) - DKA , lactic acidosis
- Is GFR low (high serum creatinine)? – AKI / CKD
- High plasma osmolal gap – methanol, ethylene glycol
- Sepsis / shock – Lactic acidosis

Normal anion gap met acidosis

Bicarbonate loss

- GI – Diarrhea, ureterosigmoidostomy
- Kidneys – Renal tubular acidosis

Case analysis

High anion gap met acidosis

Net gain of acid

- Is ECF volume low? **(dehydrated)** - DKA , **lactic acidosis**
- Is GFR low (high serum creatinine)? – AKI / CKD
- High plasma osmolal gap – methanol, ethylene glycol
- **Sepsis / shock – Lactic acidosis**

Normal anion gap met acidosis

Bicarbonate loss

- GI – Diarrhea, ureterosigmoidostomy
- **Kidneys – Renal tubular acidosis**
  - **Polyuria**
  - **Nephrocalcinosis**
  - **Urinary anion gap**

Diagnosis and further management

Probably – Renal Tubular Acidosis with superimposed dehydration

Further evaluation:

- Urinary anion gap
- Acid loading tests - NH_4Cl loading test
- Genetics

Treatment:

- HAGMA – fluid resuscitation to correct ECF volume
- NAGMA – Alkali supplementation

Case 3

A 4year old male child with nephrotic syndrome is brought to the ER with abdominal pain, anasarca, breathing difficulty and oliguria. BP – 128/90 mmHg. Weight – 23 kgs. Tests – Hb. 9.4, TLC –30,000, creatinine – 0.6 mg/dl, serum albumin 2.8 g/dl, AF TC – 1300 cells, 90 % polymorphs. You start the child on IV antibiotics, fluid restriction and IV diuretics and starts diuresing. After 48 hours his BP – 92/50 mmHg, weight – 19 kgs. ABG and electrolytes done now shows this:

pH – 7.3, pCO_2 –34, HCO_3 – 18, Na 140, K 3.8, Cl 90, HCO_3 18

contd….

pH – 7.3, pCO_2 –34, HCO_3 – 18, Na 140, K 3.8, Cl 90, HCO_3 18

STEP 1 - pH

contd….

pH – 7.3, pCO_2 –34, HCO_3 – 18, Na 140, K 3.8, Cl 90, HCO_3 18

STEP 1 - pH

Acidemia

contd….

pH – 7.3, pCO_2 –34, HCO_3 – 18, Na 140, K 3.8, Cl 90, HCO_3 18

STEP 1 - pH

Acidemia

STEP 2 – Direction of pH and pCo2

contd….

pH – 7.3, pCO_2 –34, HCO_3 – 18, Na 140, K 3.8, Cl 90, HCO_3 18

STEP 1 - pH

Acidemia

STEP 2 – Direction of pH and pCo_2

Metabolic (same direction)

contd….

pH – 7.3, pCO_2 –34, HCO_3 – 18, Na 140, K 3.8, Cl 90, HCO_3 18

STEP 1 - pH

Acidemia

STEP 2 – Direction of pH and pCo2

Metabolic (same direction)

STEP 3 – Compensation (Winter's formula)

contd….

pH – 7.3, pCO_2 –34, HCO_3 – 18, Na 140, K 3.8, Cl 90, HCO_3 18

STEP 1 - pH

Acidemia

STEP 2 – Direction of pH and pCo2

Metabolic (same direction)

STEP 3 – Compensation (Winter's formula)

PCo2 = 1.5(18)+8 ± 2 = **35 ±2 (33-37)**

contd….

pH – 7.3, pCO_2 –34, HCO_3 – 18, Na 140, K 3.8, Cl 90, HCO_3 18

Metabolic acidosis with adequate respiratory compensation

contd....

pH – 7.3, pCO_2 –34, HCO_3 – 18, Na 140, K 3.8, Cl 90, HCO_3 18

Metabolic acidosis with adequate respiratory compensation

STEP 4 - ANION GAP

contd....

pH – 7.3, pCO2 –34, HCO3 – 18, Na 140, K 3.8, Cl 90, HCO3 18

Metabolic acidosis with adequate respiratory compensation

STEP 4 - ANION GAP

Na - (Cl + Hco3)

contd....

pH – 7.3, pCO2 –34, HCO3 – 18, Na 140, K 3.8, Cl 90, HCO3 18

Metabolic acidosis with adequate respiratory compensation

STEP 4 - ANION GAP

Na - (Cl + Hco3)

140 –(90+ 18) = **32 (high AG)**

contd....

pH – 7.3, pCO2 –34, HCO3 – 18, Na 140, K 3.8, Cl 90, HCO3 18

Metabolic acidosis with adequate respiratory compensation

STEP 4 - ANION GAP

Na - (Cl + Hco3)

140 –(90+ 18) = **32 (high AG)**

STEP 5 – DELTA RATIO

contd....

pH – 7.3, pCO_2 –34, HCO_3 – 18, Na 140, K 3.8, Cl 90, HCO_3 18

Metabolic acidosis with adequate respiratory compensation

STEP 4 - ANION GAP

Na - (Cl + Hco3)

140 –(90+ 18) = **32 (high AG)**

STEP 5 – DELTA RATIO

Δ AG/ΔHCo3

contd....

pH – 7.3, pCO2 –34, HCO3 – 18, Na 140, K 3.8, Cl 90, HCO3 18

Metabolic acidosis with respiratory compensation

STEP 4 - ANION GAP

Na - (Cl + Hco3)

140 –(90+18) = **32 (high AG)**

STEP 5 – DELTA RATIO

Δ AG/ΔHCo3 = (32-7.5)/(24-18)

24.5/6 = 4.08

contd....

pH – 7.3, pCO2 –34, HCO3 – 18, Na 140, K 3.8, Cl 90, HCO3 18

Metabolic acidosis with respiratory compensation

STEP 4 - ANION GAP

Na - (Cl + Hco3)

140 –(90+18) = **32 (high AG)**

STEP 5 – DELTA RATIO

Δ AG/ΔHCo3 = (32-7.5)/(24-18)

24.5/6 = 4.08

contd....

pH – 7.3, pCO2 –34, HCO3 – 18, Na 140, K 3.8, Cl 90, HCO3 18

Metabolic acidosis with respiratory compensation

STEP 4 - ANION GAP

Na - (Cl + Hco3)

140 –(90+18) = **32 (high AG)**

Sr. albumin	Normal AG
4	10
3	7.5
2	5

STEP 5 – DELTA RATIO

Δ AG/ΔHCo3 = (32-7.5)/(24-18)

24.5/6 = 4.08

DELTA RATIO

Unit change in Δ AG = Unit change in Δ HCO3

Normal Δ ratio - 1-2 --> Isolated High AG Metabolic Acidosis (HAGMA)

Δ ratio < 1 ---> associated Normal AG Metabolic Acidosis (NAGMA)

Δ ratio > 2 ---> associated Metabolic alkalosis

Our case:

Δ AG/Δ HCo3 = 24.5/6 = 4.08

(**ΔAG > Δ HCO3,** HCO3 has not decreased enough to compensate for ΔAG)

DELTA RATIO

Unit change in Δ AG = Unit change in Δ HCO3

Normal Δ ratio - 1-2 --> Isolated High AG Metabolic Acidosis (HAGMA)

Δ ratio < 1 ---> associated Normal AG Metabolic Acidosis (NAGMA)

Δ ratio > 2 ---> associated Metabolic alkalosis

Our case:

Δ AG/Δ HCo3 = 4.08

(**ΔAG > Δ HCO3,** HCO3 has not decreased enough to compensate for ΔAG)

Associated metabolic alkalosis

Case analysis

A 4year old male child with nephrotic syndrome is brought to the ER with abdominal pain, anasarca, breathing difficulty and oliguria. BP – 128/90 mmHg. Weight – 23 kgs. Tests – Hb. 9.4, TLC –30,000, creatinine – 0.6 mg/dl, serum albumin 2.8 g/dl, AF TC – 1300 cells, 90 % polymorphs. You start the child on IV antibiotics, fluid restriction and IV diuretics. After 48 hours his BP – 92/50 mmHg, weight – 19 kgs.

METABOLIC ACIDOSIS WITH ADEQUATE RESPIRATORY COMPENSATION

HIGH ANION GAP + ASSOCIATED METABOLIC ALKALOSIS

Case analysis

A 4year old male child with **nephrotic syndrome** is brought to the ER with abdominal pain, anasarca, breathing difficulty and oliguria. BP – **128/90 mmHg. Weight – 23 kgs**. Tests – Hb. 9.4, **TLC –30,000**, creatinine – 0.6 mg/dl, serum albumin 2.8 g/dl, AF TC – 1300 cells, 90 % polymorphs. You start the child on IV antibiotics, **fluid restriction and IV diuretics.**

After 48 hours his **BP – 92/50 mmHg, weight – 19 kgs**.

METABOLIC ACIDOSIS WITH ADEQUATE RESPIRATORY COMPENSATION

HIGH ANION GAP + ASSOCIATED METABOLIC ALKALOSIS

Case analysis

High anion gap met acidosis

Net gain of acid

- Is ECF volume low? (dehydrated) - DKA , lactic acidosis
- Is GFR low (high serum creatinine)? – AKI / CKD
- High plasma osmolal gap – methanol, ethylene glycol
- Sepsis / shock – Lactic acidosis

Metabolic alkalosis

Volume depletion (Urinary Chloride)

- GI loss of Cl (low urinary Cl) – vomiting, NG suction
- Renal loss of Cl (high urinary Cl) – Diuretics, Bartter's or Gitelmann's syndrome

Volume expanded state:

(primary or secondary hyperaldosteronism)

- High PRA or Low PRA states

Case analysis

High anion gap met acidosis

Net gain of acid

- Is ECF volume low? **(dehydrated)** - DKA , lactic acidosis
- Is GFR low (high serum creatinine)? – AKI / CKD
- High plasma osmolal gap – methanol, ethylene glycol
- **Sepsis / shock – Lactic acidosis**

Metabolic alkalosis

Volume depletion (Urinary Chloride)

- GI loss of Cl (low urinary Cl) – vomiting, NG suction
- Renal loss of Cl (high urinary Cl) – **Diuretics,** Bartter's or Gitelmann's syndrome

Volume expanded state:

(primary or secondary hyperaldosteronism)

- High PRA or Low PRA states

Diagnosis and further management

Spontaneous bacterial peritonitis/Low ECF – Metabolic acidosis

Aggressive diuresis - metabolic alkalosis

Further evaluation:

- Urinary chloride – **high**

Treatment:

- Control infection
- Stop diuretics
- Give chloride rich fluids – normal saline