Discussion / Answers

PH
7.35-7.45

< 7.35
Acidosis

Respiratory PaCO2 > 40

Metabolic HCO3 < 24

CNS:
- CVA
- Hge/Drugs
- Sleep apnea

Nervous:
- ALS, Neuropathy, botulism, diaphragm paralysis

N-M junction: Myasthenia

Thorax:
- kyphosis/achosis/pleural effusions/Asthma/COPD

Calculate Anion Gap (AG)

\[ \text{Na} - (\text{HCO}_3 + \text{Cl}) \text{ Normal 10-12} \]

AG > 12
MUDPILES
- Methanol
- Uremia
- DKA
- Propylene glycol
- Iron/INH
- Lactic acid
- Ethanol
- Salicylates

AG < 12

Diarrhea
- RTA
- Acetazolamide
- Ureteral diversion
- TPN

> 7.45
Alkalosis

Respiratory PaCO2 < 35

Metabolic HCO3 > 28

High A-a gradient:
- Pneumonia
- Asthma
- PE
- CHF

Normal A-a gradient:
- Severe
- Salicylates
- Pain/Angina
- Central hyperventilation

Chloride responsive (Urine Cl < 10):
- Vomiting
- Dehydration
- Diuretics

Chloride responsive (Urine Cl > 20):
- Hypokalemia
- Hyperaldosteronism
- Cushing syndrome
- Steroids
Compensation

Respiratory compensation for Metabolic Acidosis

Winter's formula: \[ \text{PaCO}_2 = (\text{HCO}_3 \times 1.5) + 8 \pm 2 \]
Or
1 meq/L decrease in HCO3 \[ \rightarrow \] 1 mmHg decrease in PaCO2
Or
\[ \text{PaCO}_2 = \text{last 2 digits of PH} \]

Respiratory compensation for Metabolic Alkalosis

\[ \text{PaCO}_2 = 0.7 \times (\text{HCO}_3) + 21 \text{ mmHg} \]
Or
1 meq/L increase in HCO3 \[ \rightarrow \] 1 mmHg increase in PaCO2
Or
\[ \text{PaCO}_2 = \text{HCO}_3 + 15 \]
(If \( \text{PaCO}_2 > 50 \), not compensation, but additional primary respiratory acidosis)

Metabolic compensation for Respiratory Acidosis

Acute (1-4 days): Each 10 increase in PaCO2 \[ \rightarrow \] 1-2 increase in HCO3
Chronic (> 4 days): Each 10 increase in PaCO2 \[ \rightarrow \] 4-5 increase in HCO3

Metabolic compensation for Respiratory Alkalosis

Acute (1-4 days): Each 10 decrease in PaCO2 \[ \rightarrow \] 1-2 decrease in HCO3
Chronic (> 4 days): Each 10 decrease in PaCO2 \[ \rightarrow \] 4-5 increase in HCO3
Interpreting Acid-Base

1) PH: Acidosis or Alkalosis
2) 1ry problem: Metabolic or Respiratory
3) Adequate compensation or not
   (e.g. if metabolic acidosis with HCO3 10, then expected PaCO2 should be 21-25, if PaCO2 17, then there is additional 1ry respiratory alkalosis, or if PaCO2 30, then additional 1ry respiratory acidosis)
4) Additional 1ry problems: in AG metabolic acidosis, calculate Delta Gap/Delta HCO3 (ΔAG/ΔHCO3) should be around 1
   < 1 additional non-AG metabolic acidosis
   >1 additional metabolic alkalosis

   e.g. Na 120, HCO3 10, Cl 90
   AG 20, then ΔAG = 10 (20-10)
   HCO3, 10 then ΔHCO3 = 14 (24-10)
   ΔAG/ΔHCO3 10/14: <1 then additional metabolic acidosis
Important Notes

- Each change of 10 PaCO2 → PH changes by 0.08 in other direction
- Each change of 10 HCO3 → PH changes by 0.15 in same direction
- Each change in PH by 0.1 → K changes by 0.05 in other direction

Answers

1) B: No
This patient’s baseline PaCO2 is around 80-90 as evident by HCO3 45 (increase from normal by 21). Each increase PaCO2 by 10 chronically, the HCO3 increase by 4-5. If this is acute hypercapnia in patient with normal PaCO2 of 40, the PH would be expected to be 6.96 (each acute increase of PaCO2 by 10 the PH would decrease by 0.08)

2) D: 90
As above

3) E: 7.6
If the PaCO2 in this case drop acutely by 45 points, the patient would develop acute respiratory alkalosis on top of chronic respiratory acidosis, and the PH will increase by about 3.6 (45 x 0.08) to about 7.66 which is extremely dangerous as patient can develop seizures or fatal cardiac arrhythmias

4) B: No
According to winter’s formula, the expected PaCO2 IS 18-22 (PaCO2 = 1.5 (HCO3) + 8 ± 2
Since this patient’s PaCO2 is 14, he is overcompensating and has additional acute respiratory alkalosis (e.g. sepsis, pneumonia, salicylate toxicity, etc.)
5) C: 20
As above

6) C: Primary metabolic acidosis and respiratory alkalosis
As above

7) D: Emergent Intubation
Though emergent dialysis and nebulized bronchodilators would reduce K but will take long time, also patient has normal renal function. Calcium does not change the potassium level but is protective to the heart from hyperkalemia. This patient has acute respiratory acidosis, and the K increase (gets out of the cells into the serum) is proportional to the drop in PH (K increase by 0.5 meq for each 0.1 drop in PH). Emergent intubation and decreasing the PaCO2 back to within normal levels will normalize the K level.

8) B: 13-15
As in question 4. The winters formula PaCO2 = (5 X 1.5) + 8 ± 2

9) B: Primary metabolic alkalosis and respiratory acidosis
PH is 7.52 is alkalotic, the HCO3 is elevated to 40. PaCO2 compensation should be: 0.7 (HCO3) + 21 = 49, so PaCO2 of 55 is considered additional primary acute respiratory acidosis.

10 C: Stop diuretics
As the above question, the patient has developed acute metabolic alkalosis 2ry to excessive diuretics with good respiratory compensation, so stopping the diuretics is the best option. Adding acetazolamide will induce metabolic acidosis though might correct the PH slowly, it wouldn’t solve the primary problem of dehydration, obviously increasing diuretics will additionally worsen the problem, placing the patient on NIPPV for mild increase PaCO2 will cause respiratory alkalosis and will worsen the PH.