**70-YEAR-OLD MAN WITH CONFUSION**

**AUTHOR & E-MAIL LATEST REVISION**

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**MAIN LEARNING POINTS**

1-Systematic acid-base interpretation

2-Differential diagnosis of metabolic acidosis with elevated anion gap

3-Calculation of effective osmolarity and recognition of hyperglycemic hyperosmolar syndrome

**INTRODUCTION**

“A 70-year-old man with type 2 diabetes has been brought to the ED via ambulance. Bedside blood tests including blood gases are taken. How du you interpret them?”

**DISCUSSION**

**1-Anion Gap**

The sum of all cations in the blood is always equal to the sum of all anions in the blood in order to preserve electrical neutrality. When Na, Cl and HCO3 are "removed" from the blood, the number of mmol/L of anions left normally exceeds the number of mmol/L of cations by 6 – 12 mmol/L. This anion excess is referred to an the “anion gap.” When the anion gap is increased, it suggests the presence of one or several anions that are normally not present in the blood. The mnemonic for the differential diagnosis is MUDPILES (Methanol/Metformin, Uremia, Diabetic ketoacidosis, Propylene glycol/Paraglutamic acid, Iron/Isoniazid, Lactate, Ethylene glycol/Ethanol ketoacidosis, Salicylates/Solvents/Starvation ketoacidosis) [[1](#_ENREF_1)].

**2-Delta Gap**

This patient’s anion gap (Na - Cl - HCO3) is 19 mmol/L. A normal anion gap in a 70 year-old is 12 mmol/L. The patient has an anion excess of 19 – 12 mmol/L. This “excess anion gap” is also referred to as the “delta gap.” The lactate of 5.5 mmol/L accounts for most of delta gap, and thereby the presence of ketones (and hence diabetic ketoacidosis) can be ruled-out.

**3-HCO3 + Delta Gap**

Adding the HCO3 to the delta gap can reveal an underlying metabolic alkalosis (if the sum exceeds 26 mmol/L) or an underlying hyperchloremic (non-anion gap) metabolic acidosis (if the sum is less than 22 mmol/L. 7 + 14 is 21 mmol/L, suggesting the presence of a hyperchloremic metabolic acidosis, which could be due to gastrointestinal loss of HCO3 (e.g. diarrhea) or renal loss of HCO3 (e.g. renal tubular acidosis) [[1](#_ENREF_1)].

**4-Effective Osmolarity**

Effective osmolarity is calculated as (2 x Na) + glucose [[2](#_ENREF_2)]. Effective osmolarity > 320 mmol/L is consistent with HHS [[3](#_ENREF_3)].

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**ACID-BASE INTERPRETATION**

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| --- | --- |
| * Acidosis/Alkalosis? | * Metabolic acidosis (pH < 7.38 + HCO3 < 22) [[4](#_ENREF_4)] |
| * Compensation? | * The ∆HCO3 is 24 - 14 = 10. The expected ∆pCO2 is 10 x 0.16 = 1.6 [[5](#_ENREF_5)]. Hence the expected pCO2 is 5.3 - 1.6 = 3.7. The actual pCO2 is 3.2. Hence the patient also has a respiratory alkalosis. |
| * Ions? | * Anion gap 134 – 101 – 14 = 19 mmol/L * Delta gap 7 mmol/L (assuming AG of 12 mmol/L) * HCO3 + delta gap 14 + 7 = 21. Hence hyperchloremic metabolic acidosis also present. |
| * Diagnoses? | * The patient's effective osmolarity is 2xNa + Glucose = 327, which exceeds 320. Hence the patient has hyperglycemic hyperosmolar syndrome * The differential diagnosis of the metabolic acidosis is MUDPILES. Lactate accounts for most of the delta gap. The excess delta gap may be accounted for by uremia. The cause of the lactate is unclear, but shock due to sepsis or dehydration are likely in the context of HHS. * The cause of the respiratory alkalosis is unclear, but it could be caused by the infection that triggered the HHS. * The cause of the hyperchloremic metabolic acidosis is unclear (diarrhea? renal tubular acidosis?) |

**QUESTIONS**

**What is the patient's effective serum osmolarity?**

* (2 x Na) + glucose = 327 mmol/L
* Effective serum osmolarity > 320 mmol/L is consistent with Hyperglycemic Hyperosmolor Syndrome (HHS)

**Does the patient have diabetic ketoacidosis?**

* Unlikely: diabetic ketoacidosis primarily affects patients with type 1 diabetes.
* The delta gap of 7 mmol/L is for the most part accounted for by the elevated lactate.

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