HIGH ANION GAP METABOLIC ACIDOSIS

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INTRODUCTION

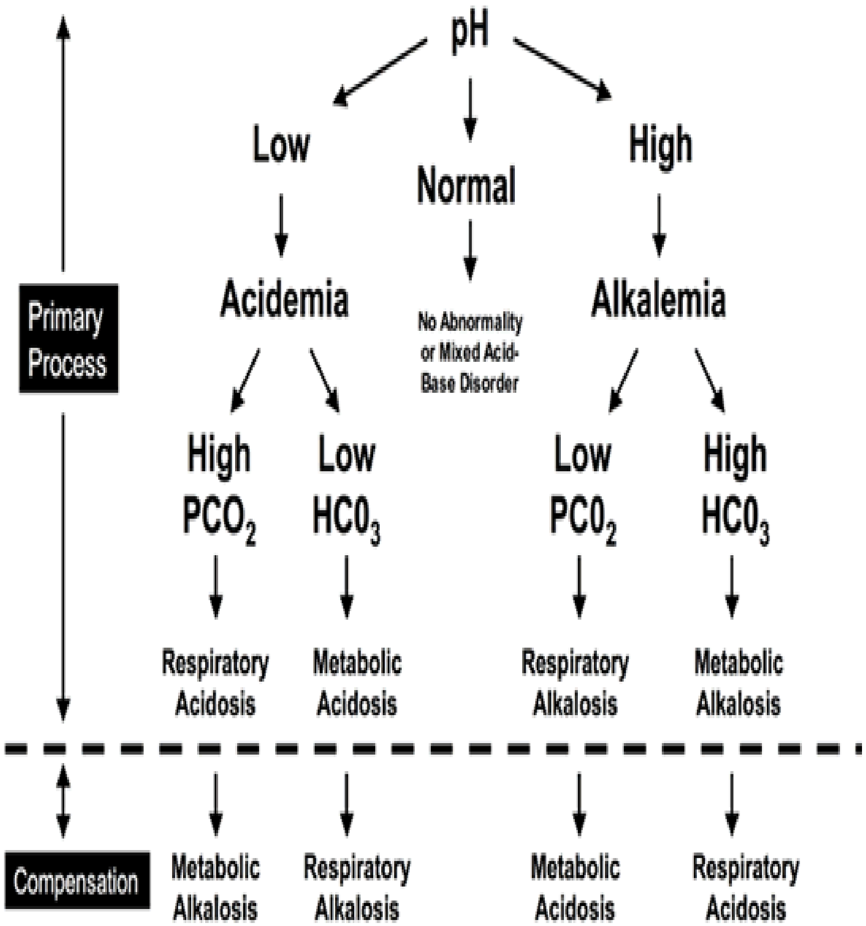
- High Anion Gap Metabolic Acidosis (**HAGMA**) is a medical condition characterized by acidemia and an increased **anion gap**, which occurs when the body accumulates "unmeasured" acidic anions that consume bicarbonate.
- **Formula:**

$$AG = Na - (Cl + HCO{-}3)$$

- **Normal Range:** Typically **8 to 12 mEq/L**.
- **Significance:** A high anion gap (usually **>12 mEq/L**) indicates that unmeasured organic acids—such as lactate or ketones—are present.

BASICS

Figure 2: Primary And Compensatory Processes



Normal Arterial Blood Gas Values*

pH	7.35 - 7.45
$PaCO_2$	35 - 45 mm Hg
PaO_2	70 - 100 mm Hg **
SaO_2	93 - 98%
HCO_3^-	22 - 26 mEq/L
%MetHb	< 2.0%
%COHb	< 3.0%
Base excess	-2.0 to 2.0 mEq/L
CaO_2	16 - 22 ml O_2/dl

* At sea level, breathing ambient air

** Age-dependent

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- **Corrected Anion Gap:** An adjustment for **hypoalbuminemia** (low protein), which can mask a high anion gap.

 Calculation: For every 1 g/dL decrease in albumin below 4.0 g/dL, the anion gap falls by about 2.5 mEq/L.

- **Osmolar Gap (OG):** The difference between measured and calculated serum osmolality. A gap **>10 mOsm/kg** suggests the presence of unmeasured toxic alcohols like methanol or ethylene glycol.

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- **Delta Gap (Delta-Delta):**
- A ratio comparing the increase in the anion gap to the decrease in bicarbonate.
- It identifies **mixed acid-base disorders.**

$$\textbf{DELTA RATIO} = \frac{\Delta \text{ anion gap}}{\Delta \text{ HCO}_3^-} = \frac{[\text{AG} - 12]}{[24 - \text{HCO}_3^-]}$$

< 0.4	Hyperchloraemic non-anion gap metabolic acidosis
0.4 - 0.8	HAGMA + NAGMA [may be isolated renal failure]
1 -2	uncomplicated HAGMA
> 2	Metabolic acidosis w/ pre-existing elevated HCO3- [metabolic alkalosis or respiratory acidosis]

CAUSES OF HAGMA

High Anion Gap Metabolic Acidosis (HAGMA)

M: methanol
U: uremia
D: diabetic ketoacidosis (DKA)
P: phenformin, paraldehyde
I : INH, iron
L: lactic acid
E: ethanol, ethylene glycol
S: salicylates

G: glycols (propylene glycol and ethylene glycol)
O: 5-oxoproline (associated with acetaminophen use)
L : L-lactate
D: D-lactate (short bowel syndrome)
M: methanol
A: aspirin
R: renal failure
K: ketoacidosis (diabetic/alcohol/starvation)

CAUSES OF NORMAL/LOW AG ACIDOSIS

Table 29.5 Most common causes of normal AG metabolic acidosis

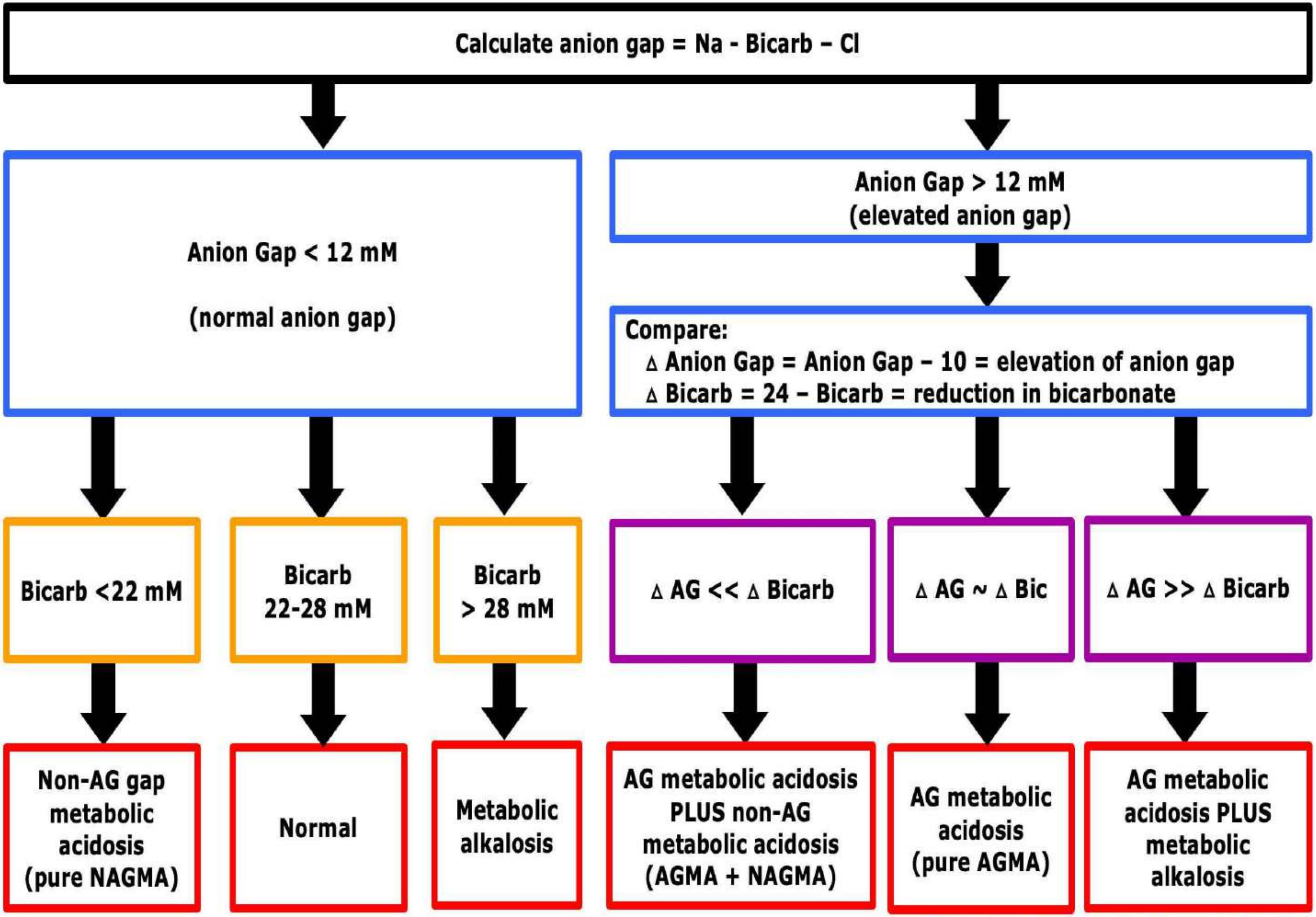
Cause	Mechanism
Diarrhea	Loss of HCO_3^- in stool
Ureterosigmoidostomy, ileal conduit	Loss of HCO_3^- in stool
Carbonic anhydrase inhibitors	Loss of HCO_3^- in urine
Recovery phase of ketoacidosis	Less HCO_3^- synthesis from decreased availability of ketones
Chronic kidney diseases (stages G4–G5)	Decrease in NH_3 excretion
Proximal renal tubular acidosis (type 2)	Loss of HCO_3^- in urine
Distal renal tubular acidosis (type 1)	Decreased renal acid secretion
Distal renal tubular acidosis (type 4)	Decreased acid secretion and low NH_3 production
Dilutional acidosis	Increased cl^- due to normal saline administration
Cholestyramine	Release of cl^- in exchange for HCO_3^-

Table 29.6 Most common causes of low AG metabolic acidosis

Cause	Mechanism
Hypoalbuminemia	Decreased number of anions
IgG myeloma	Increased number of cations
[a]Bromide intoxication	Bromide measured as chloride
Salicylate overdose	Salicylate measured as chloride
Hypercalcemia	Increased number of cations
Hypermagnesemia	Increased number of cations
Lithium toxicity	Increased number of cations
Hypertriglyceridemia	Different laboratory analysis

[a]Negative AG

Approach to diagnosis of metabolic pH abnormalities



-The Internet Book of Critical Care, by @PulmCrit

Algorithm recommended for etiological diagnosis of metabolic acidosis