**National Institute of Health (NIH)**

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5849971/>

**Wikipedia**

<https://en.wikipedia.org/wiki/Acid%E2%80%93base_disorder>

**National Institute of Health (NIH)**   
<https://www.ncbi.nlm.nih.gov/books/NBK482146/>

**KGMU**

<https://www.kgmu.org/download/virtualclass/physiology/L11_Acid_base_disorders.pdf>

**ntroduction**

Acid-base disorders, including metabolic acidosis, are disturbances in the homeostasis of plasma acidity. Any process that increases the serum hydrogen ion concentration is a distinct acidosis. The term acidemia is used to define the total acid-base status of the serum pH. For example, a patient can have multiple acidoses contributing to a net acidemia. Its origin classifies acidosis as either a respiratory acidosis which involves changes in carbon dioxide, or metabolic acidosis which is influenced by bicarbonate (HCO3).[[1][2][3]](https://www.ncbi.nlm.nih.gov/books/NBK482146/)

Metabolic acidosis is characterized by an increase in the hydrogen ion concentration in the systemic circulation resulting in a serum HCO3 less than 24 mEq/L. Metabolic acidosis is not a benign condition and signifies an underlying disorder that needs to be corrected to minimize morbidity and mortality. The many etiologies of metabolic acidosis are classified into 4 main mechanisms: increased production of acid, decreased excretion of acid, acid ingestion, and renal or gastrointestinal (GI) bicarbonate losses.[[4][5][6]](https://www.ncbi.nlm.nih.gov/books/NBK482146/)

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**Etiology**

Determining the type of metabolic acidosis can help clinicians narrow down the cause of the disturbance. Acidemia refers to a pH less than the normal range of 7.35 to 7.45. In addition, metabolic acidosis requires a bicarbonate value less than 24 mEq/L. Further classification of metabolic acidosis is based on the presence or absence of an anion gap, or concentration of unmeasured serum anions. Plasma neutrality dictates that anions must balance cations to maintain a neutral charge. Therefore, sodium (Na), the primary plasma cation, is balanced by the sum of the anions bicarbonate and chloride in addition to the unmeasured anions, which represent the anion gap. Unmeasured anions include lactate and acetoacetate, and these are often some of the main contributors to metabolic acidosis.[[7][8][9]](https://www.ncbi.nlm.nih.gov/books/NBK482146/)

* Anion gap (AG) = [Na] –([Cl] + [HCO3])

Anion gap metabolic acidosis is frequently due to anaerobic metabolism and lactic acid accumulation. While lactate is part of many mnemonics for metabolic acidosis, it is important to distinguish it is not a separate etiology, but rather a consequence of a condition.

Mnemonic for anion gap metabolic acidosis differential: CAT MUDPILES

* C: Cyanide and carbon monoxide poisoning
* A: Arsenic
* T: Toluene
* M: Methanol, Metformin
* U: Uremia
* D: DKA
* P: Paraldehyde
* I: Iron, INH
* L: Lactate
* E: Ethylene glycol
* S: Salicylates

Non-gap metabolic acidosis is primarily due to the loss of bicarbonate, and the main causes of this condition are diarrhea and renal tubular acidosis. Additional and rarer etiologies include Addison’s disease, ureterosigmoid or pancreatic fistulas, acetazolamide use, and hyperalimentation through TPN initiation. GI and renal losses of bicarbonate can be distinguished via urine anion gap analysis:

* Urine AG = Urine Na + Urine K – Urine Cl

A positive value is indicative of renal bicarbonate loss, such as renal tubular acidosis. Negative values are found with non-renal bicarbonate losses, such as diarrhea.

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**Epidemiology**

Metabolic acidosis is a sign of underlying pathology, and while it is not uncommon, especially in acutely ill patients, the overall prevalence in the population is uncertain.

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**Pathophysiology**

Hydrogen ion concentration is determined by acid ingestion, acid production, acid excretion, and renal and GI bicarbonate losses. Buffers such as bicarbonate minimize significant pH alterations.[[10][11]](https://www.ncbi.nlm.nih.gov/books/NBK482146/)

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**History and Physical**

A focused history can elicit potential causes of acid-base disturbances such as vomiting, diarrhea, medications, possible overdoses and chronic conditions with a predisposition to acidosis including diabetes mellitus.

The physical exam reveals signs unique to each cause such as dry mucous membranes in the patient with diabetic ketoacidosis. Hyperventilation may also be present as a compensatory respiratory alkalosis to assist with PCO2 elimination and correction of the acidemia. Compensatory reactions do not completely correct a disturbance to the normal pH range, however.

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**Evaluation**

**Interpretation Steps**

Acid-base interpretation is crucial to identify and correct disturbances in acid-base equilibrium that have profound consequences on patient health. The following steps use lab values and equations to determine if a patient has metabolic acidosis and any additional acid-base disturbances.

*Step 1: pH, determine if the acid-base status is acidemia or alkalemia*

Blood pH is maintained within a narrow range for optimization of physiological functions. Acid-base equilibrium is achieved within a pH range of 7.35 to 7.45. Blood pH distinguishes between acidemia (pH less than 7.35) and alkalemia (pH greater than 7.45)

*Step 2: CO2, determine if the disturbance is metabolic or respiratory*

The pCO2 determines whether an acidosis is respiratory or metabolic in origin. For a respiratory acidosis, the pCO2 is greater than 40 to 45 due to decreased ventilation. Metabolic acidosis is due to alterations in bicarbonate, so the pCO2 is less than 40 since it is not the cause of the primary acid-base disturbance. In metabolic acidosis, the distinguishing lab value is a decreased bicarbonate (normal range 21 to 28 mEq/L).

*Step 3: Determine if there is anion gap or non-anion gap metabolic acidosis*

* AG= Na – (Cl + HCO3)

The normal anion gap is 12. Therefore, values greater than 12 define an anion gap metabolic acidosis.

*Step 4: CO2, assess if respiratory compensation is appropriate*

Respiratory compensation is the physiologic mechanism to help normalize a metabolic acidosis, however, compensation never completely corrects an acidemia. It is important to determine if there is adequate respiratory compensation or if there is another underlying respiratory acid-base disturbance. Winter's formula is the equation used to determine the expected CO2 for adequate compensation.

* Winter’s formula: Expected CO2 = (Bicarbonate x 1.5) + 8 +/- 2

If the patient’s pCO2 is within the predicted range, then there is no additional respiratory disturbance. If the pCO2 is greater than expected, this indicates an additional respiratory acidosis. If the pCO2 is less than expected, there is an additional respiratory alkalosis occurring.

*Step 5: Evaluate for additional metabolic disturbances*

A delta gap must be determined if an anion gap is present.

* Delta gap = Delta AG – Delta HCO3 = (AG-12) – (24-bicarbonate)

If the gap is less than -6, then a NAGMA is present.

If the gap is greater than 6, then an underlying metabolic alkalosis is present.

If the gap is between -6 and 6 then only an anion gap acidosis exists.

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**Treatment / Management**

The management of metabolic acidosis should address the cause of the underlying acid-base derangement. For example, adequate fluid resuscitation and correction of electrolyte abnormalities are necessary for sepsis and diabetic ketoacidosis. Other therapies to consider include antidotes for poisoning, dialysis, antibiotics, and bicarbonate administration in certain situations.

Refer to the specific conditions for a thorough explanation of the appropriate treatment.

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**Differential Diagnosis**

The differential diagnosis depends on the cause of metabolic acidosis. Etiology of the derangement determines the characteristics that influence the differential diagnosis.

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**Prognosis**

The prognosis of metabolic acidosis is dependent upon the etiology and the acid-base derangement. The prognosis is poor if derangements are large and vitals are unstable.

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**Pearls and Other Issues**

Metabolic acidosis is a clinical disturbance defined by a pH less than 7.35 and a low HCO3 level.

The anion gap helps determine the cause of the metabolic acidosis. An elevated anion gap metabolic acidosis can be caused by salicylate toxicity, diabetic ketoacidosis, and uremia (MUDPILES). Non-Gap metabolic acidosis is due to GI loss of bicarbonate (diarrhea) or a failure of kidneys to excrete acid.

Lab tests that help evaluate metabolic acidosis are those that assess renal and lung function including electrolytes, venous or arterial blood gas, and toxin levels such as salicylate if an overdose is suspected.

Treatment of metabolic acidosis is case-dependent.

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**Enhancing Healthcare Team Outcomes**

The management of metabolic acidosis should address the cause of the underlying acid-base derangement. Because there are many causes, the electrolyte disorder is best managed by an interprofessional teamt that also includes nurses and pharmacists. For example, adequate fluid resuscitation and correction of electrolyte abnormalities are necessary for sepsis and diabetic ketoacidosis. Other therapies to consider include antidotes for poisoning, dialysis, antibiotics, and bicarbonate administration in certain situations.

The outcomes depend on the cause, patient morbidity and response to treatment.

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**Review Questions**

* [Access free multiple choice questions on this topic.](https://www.statpearls.com/account/trialuserreg/?articleid=17095&utm_source=pubmed&utm_campaign=reviews&utm_content=17095)
* [Comment on this article.](https://www.statpearls.com/articlelibrary/commentarticle/17095/?utm_source=pubmed&utm_campaign=comments&utm_content=17095)

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