# ACID BASE BALANCE

## in Hemodialysis Patients with End Stage Renal Disease

FACT SHEET 1

PARTNERS in Quality Care

### What is an acid-base imbalance?

There are four types of acid-base disturbances: metabolic acidosis, respiratory acidosis, metabolic alkalosis, and respiratory alkalosis. As the name implies, respiratory acidosis and alkalosis can be attributed to respiratory function; metabolic disturbances can be attributed to a decrease or increase in blood bicarbonate. These four types of acid-base imbalance can generally be differentiated based on arterial blood gas parameters (Rose, 2001; White, 2005).

### What are the causes of metabolic acidosis and metabolic alkalosis?

Metabolic acidosis occurs when an excess $H^+$ concentration builds up in the blood such that the pH falls below normal (Kallenbach, 2005; White, 2005). The elevated pH (or low $H^+$ concentration) associated with metabolic alkalosis results from a rise in the plasma bicarbonate concentration, and can be produced either by bicarbonate administration or by $H^+$ loss (Rose, 2001).

## LABORATORY VALUES IN METABOLIC ACID-BASE IMBALANCES

(compiled from White, Daugirdas, Galla, Ishiguchi, Merck)

| CONDITION | pH | $PACO_2$ | $HCO_3^-$ |
|---|---|---|---|
| Normal | 7.35 – 7.45 | 35 to 45 mm Hg | 24 to 28 mEq/L |
| Metabolic acidosis | < 7.35 | 35 to 45 mm Hg | < 24mEq/L |
| Severe | < 7.00 | | < 10 mEq/L |
| Respiratory acidosis | < 7.35 | > 45 mm Hg | 24 to 28 mEq/L |
| Metabolic alkalosis | > 7.45 | 35 to 45 mm Hg | > 28 mEq/L |
| Severe | > 7.55 | | > 40-42 mEq/L |
| Respiratory alkalosis | > 7.45 | < 35 mm Hg | 24 to 28 mEq/L |

## CAUSES OF METABOLIC ACIDOSIS (Rose, 2001)

INCREASED $H^+$ LOAD OR $HCO_3^-$ LOSS

- Lactic acidosis
- Ketoacidosis
- Gastrointestinal $HCO_3^-$ loss
  - Diarrhea
  - Pancreatic, biliary, or intestinal fistulas
  - Ureterosigmoidostomy
  - Cholestyramine
- Ingestions
  - Salicylates
  - Methanol or formaldehyde
  - Ethylene glycol
  - Paraldehyde
  - Sulfur
  - Toluene
  - Ammonium chloride
  - Hyperalimentation fluids

## CAUSES OF METABOLIC ALKALOSIS (Rose, 2001)

DECREASED $H^+$ LOAD OR $HCO_3^-$ GAIN

- Retention of $HCO_3^-$
  - Administration of $HCO_3^-$
  - Organic ions (lactate, citrate, acetate)
- Gastrointestinal $H^+$ loss
  - Vomiting
  - Nasogastric suction
  - Chronic antacid therapy
  - Laxative abuse
  - Congenital chloridorrhea
- Intracellular $H^+$ shift
  - Hypokalemia
  - Refeeding of carbohydrate after fast
- Urinary $H^+$ loss
  - Diuretics
  - Intravenous carbenicillin or penicillin
  - Hypercalcemia

Daugirdas, J.T., Blake, P.G., Ing, T.S. (Eds) (2007). *Handbook of Dialysis, 4th Edition.* Philadelphia, PA: Lippincott Williams & Wilkins. / Galla, J.H. (2000). Metabolic Alkalosis. *Journal of the American Society of Nephrology,* 11, 369-375. / Ishiguchi, T., Mikita, N., Iwata, T., et al (2004). Myoclonus and metabolic alkalosis from licorice in antacid. *Internal Medicine,* 43, 59-62. / Merck Manuals Online Medical Library, Home Edition for Patients and Caregivers (revised 2003). / Acidosis. Retrieved August 24, 2007 from http://www.merck.com/mmhe/sec12/ch159/ch159b.html. / Merck Manuals Online Medical Library, Home Edition for Patients and Caregivers (revised 2003). / Alkalosis. Retrieved August 24, 2007 from http://www.merck.com/mmhe/sec12/ch159/ch159c.html. / Rose, B.D., Post, T.W. (2001). *Clinical Physiology of Acid-Base and Electrolyte Disorders, 5th Edition.* New York, NY: McGraw-Hill. / White, L. (2005). *Foundations of Basic Nursing, 2nd Edition.* New York, NY: Thomson Delmar Learning.

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## SYMPTOMS

**What are the symptoms of metabolic acidosis and metabolic alkalosis?**

Some of the symptoms of metabolic acidosis and metabolic alkalosis are presented in the adjacent tables. In severe cases, either of these acid-base imbalances could result in death.

| SYMPTOMS OF METABOLIC ACIDOSIS (Merck, 2003; Rose, 2001) | |
|---|---|
| Nausea | Confusion |
| Vomiting | Drop in blood pressure |
| Fatigue | Shock |
| Weakness | Coma |
| Drowsiness | |

| SYMPTOMS OF METABOLIC ALKALOSIS (Merck, 2003; Rose, 2001; Daugirdas, 2007) | |
|---|---|
| Weakness | Muscle cramps |
| Jitteriness | Cardiac arrhythmia |
| Muscle spasms | Sudden death |

**What is respiratory compensation?**

When pH fluctuates far enough outside of the normal range, the body will attempt to compensate to correct the problem. Two organs, the lungs and the kidneys, work to regulate the body's pH (White, 2005). When the kidneys fail to regulate pH effectively, the lungs will work to bring the pH back to normal. When metabolic acidosis occurs, respiration may become deeper and $PaCO_2$ levels will become alkaline. Alternatively, when metabolic alkalosis occurs, respiration may become shallower and $PaCO_2$ levels will become acidic (Mays, 1995).

### RESPIRATORY COMPENSATION IN METABOLIC ACID-BASE DISTURBANCES (Rose, 2001; Watson 2002)

| DISORDER | PRIMARY CHANGE | COMPENSATORY RESPONSE | RESULT |
|---|---|---|---|
| Metabolic acidosis | Decreased $HCO_3^-$ | 1.2 mm Hg decrease in $PaCO_2$ for every 1 mEq/L decrease in $HCO_3^-$ | Decreased $PaCO_2$ |
| Metabolic alkalosis | Increased $HCO_3^-$ | 0.6 mm Hg increase in $PaCO_2$ for every 1 mEq/L increase in $HCO_3^-$ | Increased $PaCO_2$ |

**What is the anion gap?**

The plasma anion gap is a calculated value that is useful for determining if a patient has metabolic acidosis when pH, $PaCO_2$, and $HCO_3^-$ do not provide clear indication. It is equal to the difference between the blood concentrations of the major cation, $Na^+$, and the sum of the major anions, $Cl^-$ and $HCO_3^-$, as follows:

$$\textbf{Anion gap} = [Na^+] - ([Cl^-] + [HCO_3^-])$$

The normal values for these ions are approximately 140 mEq/L, 108 mEq/L, and 24 mEq/L, respectively. The normal range of the anion gap is 5 to 11 mEq/L. A high anion gap in patients with renal failure may indicate the presence of metabolic acidosis (Rose, 2001; Das, 2003).

Das, B. (2003). Acid-base disorders. *Indian Journal of Anaesthesiology*, 47(5), 373-379. / Daugirdas, J.T., Blake, P.G., Ing, T.S. (Eds) (2007). *Handbook of Dialysis, 4th Edition.* Philadelphia, PA: Lippincott Williams & Wilkins. / Mays, D.A. (1995). Turn ABGs into child's play. *RN*, January, 36-39./ Merck Manuals Online Medical Library, Home Edition for Patients and Caregivers (revised 2003). / Acidosis. Retrieved August 24, 2007 from http://www.merck.com/mmhe/sec12/ch159/ch159b.html. / Merck Manuals Online Medical Library, Home Edition for Patients and Caregivers (revised 2003). / Alkalosis. Retrieved August 24, 2007 from http://www.merck.com/mmhe/sec12/ch159/ch159c.html. / Rose, B.D., Post, T.W. (2001). *Clinical Physiology of Acid-Base and Electrolyte Disorders, 5th Edition.* New York, NY: McGraw-Hill. / Watson, M.L. (2002). Back to basics: Acid-base disorders. *The Canadian Journal of CME*, June, 57-63. / White, L. (2005). *Foundations of Basic Nursing, 2nd Edition.* New York, NY: Thomson Delmar Learning.

 