Blood Gas Analysis

**Determine if arterial or venous**

— Venous: Jugular sample provides the best idea of whole-body status (pulmonary artery sample is ideal but not practical). Limb samples may represent local tissue bed and not whole body.

— Arterial: Dorsal metatarsal artery, femoral artery, auricular artery, or caudal artery

**Arterial sample (to assess respiratory function)**
- PaCO₂ assesses ability to ventilate
- PaO₂ assesses ability to oxygenate

**Venous sample (pulse oximetry can be used with venous blood gas to assess oxygenation)**
- PvCO₂ can suggest ventilation (about 5 mm Hg higher than PaCO₂)

**Evaluate pH to determine if acidemia or alkalemia present**

Acidemia = pH < 7.35

Metabolic = BE < -4 mmol/L (or HCO₃⁻ < 21 mEq/L)

**Respiratory Acidosis**
- Increased anion gap:
  - Ketones
  - Lactate
  - Uremia
  - Toxicity (ethylene glycol, salicylates)
- Normal anion gap:
  - HCO₃⁻ loss through kidneys or intestinal tract

**Metabolic Acidosis**
- Increased anion gap:
  - Ketones
  - Lactate
  - Uremia
  - Toxicity (ethylene glycol, salicylates)
- Normal anion gap:
  - HCO₃⁻ deficit = BE × body weight (kg) / 0.3
  - Give 1/4–1/3 of dose and recheck blood gas

**Respiratory Alkalosis**
- Hypoxemia
- Pulmonary disease
- CNS disease (stimulating respiratory center)
- Exercise, pain, stress

**Metabolic Alkalosis**
- GI obstruction with loss of H⁺, K⁺, and especially Cl⁻ in vomitus
- Loop diuretics
- NaHCO₃ administration

**Respiratory Acidosis**
- Depressed respiratory center
- Cervical spinal cord disease
- Neuromuscular disease
- Pleural space disease
- Airway obstruction
- Rarely severe pulmonary parenchymal disease

**Metabolic Acidosis**
- Correct underlying problem
- Relieve airway obstruction/restrictive disease (pleural space)
- Intubate, begin PPV

**Respiratory Alkalosis**
- Correct underlying cause
- Lacate: improve oxygen delivery to the tissues
- Ketones: Insulin therapy
- NaHCO₃ (if needed)
  - HCO₃⁻ deficit = BE × body weight (kg) / 0.3
  - Give 1/4–1/3 of dose and recheck blood gas

**Metabolic Alkalosis**
- Hypokalemic hypochloremic metabolic alkalosis: Volume expansion with 0.9% NaCl
- Loop diuretic or HCO₃⁻ therapy: No treatment, usually self-limiting

**Evaluate PCO₂ and BE for masked disturbances if pH = 7.35–7.45**

Determine if metabolic or respiratory in origin

**Respiratory = PaCO₂ > 45 mm Hg**

**Metabolic = BE < -4 mmol/L (or HCO₃⁻ < 21 mEq/L)**

**Determine if metabolic or respiratory in origin**

**Acidemia = pH < 7.35**

**Alkalemia = pH > 7.45**

**Assess for compensation (see Rules of Compensation)**

Correct underlying diseases

**Correct underlying problem**
- Relieve airway obstruction/restrictive disease (pleural space)
- Intubate, begin PPV

**Correct underlying cause**
- Lacate: improve oxygen delivery to the tissues
- Ketones: Insulin therapy
- NaHCO₃ (if needed)
  - HCO₃⁻ deficit = BE × body weight (kg) / 0.3
  - Give 1/4–1/3 of dose and recheck blood gas

**Select machine** (eg, i-STAT, abbott.com; VitalPath, heska.com)

**Investigate**

**Differential Diagnosis**

**Treatment**

**Results**

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University of Pennsylvania
This algorithm reflects canine normals. For cats, substitute feline normals for pH, BE (or HCO$_3^-$), PCO$_2$, and PO$_2$ values (Table 1).

**Rules of Compensation**

1. Change in respiratory or metabolic component of the acid-base status will normally induce opposite, compensatory change in the other to return the pH toward normal.

2. Lungs compensate rapidly by changing minute ventilation (respiratory rate/tidal volume/both) within minutes.

3. Metabolic compensation occurs via the kidneys and is much slower, starting after a few hours and requiring 4 to 5 days for maximum compensation.

4. Absence or presence and degree of compensation for respiratory disturbance can give an idea of chronicity (Table 2).

5. Overcompensation does not occur.

6. If expected compensation is absent, a mixed disturbance is present. For example, if metabolic acidosis is not accompanied by compensatory respiratory alkalosis (the CO$_2$ is normal or increased), a mixed disturbance is occurring with both metabolic acidosis and respiratory acidosis.

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### Table 1. Normal Values for Blood Gases

<table>
<thead>
<tr>
<th></th>
<th>Arterial</th>
<th>Venous</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Canine</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td>7.35–7.45</td>
<td>7.35–7.45</td>
</tr>
<tr>
<td>PO$_2$ (mm Hg)</td>
<td>90–100</td>
<td>30–42</td>
</tr>
<tr>
<td>PCO$_2$ (mm Hg)</td>
<td>35–45</td>
<td>40–50</td>
</tr>
<tr>
<td>HCO$_3^-$ (mEq/L)</td>
<td>20–24</td>
<td>20–24</td>
</tr>
<tr>
<td>BE (mmol/L)</td>
<td>-4–+4</td>
<td>-4–+4</td>
</tr>
<tr>
<td><strong>Feline</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td>7.34 ± 0.1</td>
<td>7.30 ± 0.08</td>
</tr>
<tr>
<td>PO$_2$ (mm Hg)</td>
<td>102.9 ± 15</td>
<td>38.6 ± 11</td>
</tr>
<tr>
<td>PCO$_2$ (mm Hg)</td>
<td>33.6 ± 7</td>
<td>41.8 ± 9</td>
</tr>
<tr>
<td>HCO$_3^-$ (mEq/L)</td>
<td>17.5 ± 3</td>
<td>19.4 ± 4</td>
</tr>
<tr>
<td>BE (mmol/L)</td>
<td>-6.4 ± 5</td>
<td>-5.7 ± 5</td>
</tr>
</tbody>
</table>

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### Table 2. Expected Compensatory Changes

<table>
<thead>
<tr>
<th>Disorder</th>
<th>Primary Change</th>
<th>Compensatory Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metabolic acidosis</td>
<td>↓ HCO$_3^-$</td>
<td>0.7 mm Hg decrease in PCO$_2$ for each 1 mEq/L decrease in HCO$_3^-$</td>
</tr>
<tr>
<td>Metabolic alkalosis</td>
<td>↑ HCO$_3^-$</td>
<td>0.7 mm Hg increase in PCO$_2$ for each 1 mEq/L increase in HCO$_3^-$</td>
</tr>
<tr>
<td>Acute respiratory acidosis</td>
<td>↑ PCO$_2$</td>
<td>1.5 mEq/L increase in HCO$_3^-$ for each 10 mm Hg increase in PCO$_2$</td>
</tr>
<tr>
<td>Chronic respiratory acidosis</td>
<td>↑ PCO$_2$</td>
<td>3.5 mEq/L increase in HCO$_3^-$ for each 10 mm Hg increase in PCO$_2$</td>
</tr>
<tr>
<td>Acute respiratory alkalosis</td>
<td>↓ PCO$_2$</td>
<td>2.5 mEq/L decrease in HCO$_3^-$ for each 10 mm Hg decrease in PCO$_2$</td>
</tr>
<tr>
<td>Chronic respiratory alkalosis</td>
<td>↓ PCO$_2$</td>
<td>5.5 mEq/L decrease in HCO$_3^-$ for each 10 mm Hg decrease in PCO$_2$</td>
</tr>
</tbody>
</table>

See Aids & Resources, back page, for references & suggested reading.

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BE = base excess, HCO$_3^-$ = bicarbonate, NaHCO$_3$ = sodium bicarbonate, PaCO$_2$ = partial pressure of arterial carbon dioxide, PCO$_2$ = partial pressure carbon dioxide, PO$_2$ = partial pressure oxygen, PPV = positive-pressure ventilation, PvCO$_2$ = partial pressure of venous carbon dioxide