BLOOD GAS ANALYSIS

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SELECT MACHINE

INVESTIGATION
Determine if arterial or venous
- Venous: Jugular sample provides the best idea of whole-body status. Peripheral samples may represent local tissue bed and not whole body.
- Arterial: Dorsal metatarsal artery, femoral artery, auricular artery, or caudal artery

INVESTIGATION
Arterial sample (to assess respiratory function)
- $PaCO_2$ assesses ability to ventilate
- PaO_2 assesses ability to oxygenate

INVESTIGATION
Venous sample (pulse oximetry can be used with venous blood gas to assess oxygenation)
- $PvCO_2$ can suggest ventilation (usually about 5 mm Hg higher than $PaCO_2$)

INVESTIGATION
Evaluate pH to determine if acidemia or alkalemia present

INVESTIGATION
Acidemia = pH <7.35

INVESTIGATION
Alkalemia = pH >7.45

INVESTIGATION
Determine if metabolic or respiratory in origin

INVESTIGATION
Evaluate PCO_2 and BE for masked disturbances if pH = 7.35–7.45

INVESTIGATION
Determine if metabolic or respiratory in origin

RESULTS
Respiratory = $PaCO_2$ >45 mm Hg

RESULTS
Metabolic = BE <−4 mmol/L (or HCO_3^- <21 mEq/L)

INVESTIGATION
Assess for compensation (see **Rules of Compensation**, next page)

RESULTS
Respiratory = $PaCO_2$ <35 mm Hg

RESULTS
Metabolic = BE >4 mmol/L (or HCO_3^- >27 mEq/L)

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

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

DIFFERENTIAL
Metabolic Acidosis
- Increased anion gap:
  - Ketones
  - Lactate
  - Uremia
  - Toxicity (ethylene glycol, salicylates)
- Normal anion gap:
  - HCO_3^- loss through kidneys or intestinal tract

TREATMENT
- Correct underlying cause
- Lactate: Improve oxygen delivery to the tissues
- Ketones: Insulin therapy
- $NaHCO_3$ (if needed)
  - HCO_3^- deficit = BE × body weight (kg) × 0.3
  - Give one-fourth to one-third of dose and recheck blood gas

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

TREATMENT
Correct underlying diseases

DIFFERENTIAL
Metabolic Alkalosis
- GI obstruction with loss of H^+, K^+, and especially Cl^- in vomitus
- Loop diuretics
- $NaHCO_3$ administration

TREATMENT
- Hypokalemic hypochloremic metabolic alkalosis: Volume expansion with 0.9% NaCl
- Loop diuretic or HCO_3^- therapy: No treatment, usually self-limiting

Go to the next page to see a list of key terms.

TABLE 1

NORMAL VALUES FOR BLOOD GASES

	Arterial	Venous
CANINE		
pH	7.35–7.45	7.35–7.45
PO_2 (mm Hg)	90–100	30–42
PCO_2 (mm Hg)	35–45	40–50
HCO_3^- (mmol/L)	20–24	20–24
BE (mmol/L)	−4–+4	−4–+4
FELINE		
pH	7.34 ± 0.1	7.30 ± 0.08
PO_2 (mm Hg)	102.9 ± 15	38.6 ± 11
PCO_2 (mm Hg)	33.6 ± 7	41.8 ± 9
HCO_3^- (mEq/L)	17.5 ± 3	19.4 ± 4
BE (mmol/L)	−6.4 ± 5	−5.7 ± 5

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.

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

TABLE 2

EXPECTED COMPENSATORY CHANGES

Disorder	Primary Change	Compensatory Response
Metabolic acidosis	↓ HCO_3^-	0.7 mm Hg decrease in PCO_2 for each 1 mmol/L decrease in HCO_3^-
Metabolic alkalosis	↑ HCO_3^-	0.7 mm Hg increase in PCO_2 for each 1 mmol/L increase in HCO_3^-
Acute respiratory acidosis	↑ PCO_2	1.5 mmol/L increase in HCO_3^- for each 10 mm Hg increase in PCO_2
Chronic respiratory acidosis	↑ PCO_2	3.5 mmol/L increase in HCO_3^- for each 10 mm Hg increase in PCO_2
Acute respiratory alkalosis	↓ PCO_2	2.5 mmol/L decrease in HCO_3^- for each 10 mm Hg decrease in PCO_2
Chronic respiratory alkalosis	↓ PCO_2	5.5 mmol/L decrease in HCO_3^- for each 10 mm Hg decrease in PCO_2

BLOOD GAS ANALYSIS ALTERNATIVES

Author Commentary

If blood gas analysis is not available, some information can be obtained through other tests. Pulse oximetry can be used to assess a patient's oxygenation. It must be remembered that pulse ox saturation and PaO_2 are not directly correlated; a pulse ox of 93% corresponds with a PaO_2 of 80 mm Hg and a pulse ox of 90% corresponds with a PaO_2 of 60 mm Hg. If the patient is intubated, end tidal CO_2 ($ETCO_2$) can be used to assess for hypercarbia or hypocarbia. $ETCO_2$ usually corresponds well to the $PaCO_2$, with $ETCO_2$ approximately 5 mm Hg lower than $PaCO_2$ in normal patients. In medium and large dogs, the end tidal tubing can be placed just inside the nostril of an awake, compliant patient to estimate $ETCO_2$.

If anion gap measurement is available on a chemistry screen, it can be used to detect some causes of metabolic acidosis, including those caused by ketones, lactate, and exogenous acids (eg, toxins, phosphates, sulfates). These will all cause an increase in the anion gap. If the anion gap is normal but the corrected chloride is elevated (see equation below), loss of bicarbonate via the kidneys or the large bowel may be causing a metabolic acidosis.

Additionally, the patient's ketones may be measured via either ketone strips for use with urine or a ketometer to measure serum ketones. A handheld lactate meter can be used to measure ketones. These are relatively inexpensive (typically cost several hundred United States dollars), small pieces of equipment similar to a glucometer and give results in a few minutes. Although they do not give information about pH, they can help guide fluid therapy and potentially help prognosticate in patients that are presented with a high lactate and do not respond to therapy. To detect a metabolic alkalosis, the patient's chloride concentration should be evaluated. If the corrected chloride is low, a metabolic alkalosis is likely.

Corrected Cl^- = (normal Na^+/measured Na^+) × measured Cl^-

This equation helps determine if the chloride concentration is abnormal in comparison to the sodium concentration, as normally the 2 ions will change in the same direction and to the same degree. Changes in the corrected chloride can indicate metabolic derangements.