Providing the best quality care and service for the patient, the client, and the referring veterinarian.
Normal Respiration

- Automatic and effortless.
- Constant rate and rhythm
  - To maintain control there are 4 centers that control respiration
  - In the medulla there is the respiratory pacemaker in the reticular formation, and a respiratory pacemaker the dorsal respiratory group.
    - Forced inhalation and exhalation
Normal Respiration

- Centers in the Pons
  - Pneumotaxic center.
    - This coordinates the transition between inspiration and exhalation.
    - Inhibits the inspiratory center
    - This fine tunes respiration
  - Apneustic center
    - Coordinates transition between inhalation and exhalation.
    - Stimulates inspiratory center.
  - Pneumotaxic center will over-ride
- Anterior horn cells of the spinal cord integrates all of these signals
Normal Respiration

- Control of rhythm is predominantly controlled by the autonomic nervous system.
- Carbon dioxide (CO$_2$) is the primary determinant of the respiratory drive in mammals.
  - The sensors in the brain and arterial system.
- There are chemoreceptors for oxygen but they are of secondary importance in health.
Normal Respiration

- Active movement of air into the lungs.
  - Contraction of the intercostal muscles
  - Contraction of the diaphragm
  - Drop in the intrapleural pressure
  - The lungs expand
  - Air is sucked into the lungs
Normal Respiration

- As air enters the body, it starts to get diluted with other gases in the body.
  - Ambient air has a pressure of 760 mmHg
  - Ambient oxygen is only 160 mmHg
  - In the alveolus/pulmonary vein, the pressure is 100 mmHg
  - Factors contributing to the decrease:
    - Exhaled carbon dioxide
    - Water vapor

Photo: http://en.wikipedia.org/wiki/Gas_exchange
Normal Respiration

- Gas exchange
  - Occurs by passive diffusion
  - Venous blood entering the alveolar capillary has an average oxygen concentration of 40 mmHg and an average CO$_2$ concentration of 46 mmHg.
  - As blood leaves the capillary, the average oxygen tension is about 100 mmHg and an average carbon dioxide tension of about 40 mmHg.
Normal Respiration

- Normal gas exchange occurs in about 1/3 of the available time that the blood and alveolus are in contact.
- Oxygen diffusion is the rate limiting step. Carbon dioxide will diffuse 20 times faster than the oxygen.
Dyspnea

- Labored or difficulty breathing
- Dyspnea is in response to adverse pulmonary ventilation.
- In humans dyspnea is more subjective and considered to be more like discomfort of breathing. This is more on par with pain.
- This is thought to have developed to be of use because pain usually is in response to an adverse event.
Dyspnea

- Humans with dyspnea report simultaneous other unpleasant sensory experiences.
  - Pain, nausea, thirst, hunger, etc
- However the level pain is often reported to be diminished.
  - The reason for this is thought to be an evolved survival trait.
The Dyspneic Animal

- These are animals are unstable
- Immediate action is important
- You are often very limited in what you can do initially
- Limiting stress is important
Recognizing Dyspnea

- With respiratory disease, ventilation or oxygenation or both may become impaired and the respiratory muscles must work harder to compensate. The animal’s respiratory pattern may therefore supply important clues as to the anatomical localization and nature of the respiratory tract disorder.
Non-specific Stabilization

- **Supplemental oxygen**
  - There are very few instances where this is contra-indicated.
  - Flow-by/mask oxygen is usually the first line of treatment because it is simple and fast.
    - Mask is more effective than flow-by.
    - Oxygen rate at 2 to 5 L/min
    - Tube is held 2 to 4 cm from nose.
Flow by oxygen

Non-specific stabilization

- Sedation
  - Reduces anxiety
  - Allows animal to take deeper, slower breaths
  - Can act as an antitussive
  - Analgesia
  - Need to select based on presumptive disease conditions
Sedatives

- **Butorphanol** – 0.1 to 0.6mg/kg IV or IM
  - Minimal CV depression
  - Antitussive
  - Excellent sedation
  - Not a good choice for recent trauma or patients expected to go to emergency surgery, due to relatively poor analgesia

- **Pure Mu Agonists (Hydromorphone/Morphine/Fentanyl)**
  - Minimal CV depression
  - Antitussive
  - Excellent sedation
  - Excellent analgesia
  - Hydromorphone and Morphine can induce tachypnea that can be detrimental to the patient
  - Hydromorphone and Morphine can induce vomiting
  - Fentanyl is short acting so a CRI should be initiated
Sedatives

- **Benzodiazepines – 0.1 to 0.5mg/kg**
  - Midazolam IV or IM
  - Diazepam IV only
  - Minimal CV depression
  - Excellent sedation
  - Anxiolytic

- **Acepromazine 0.02 to 0.5mg/kg IM or IV**
  - Can cause hypotension at higher doses
  - No analgesia
  - Not anxiolytic
  - Seizures???
    - Current literature says probably not
Initial Diagnostics

- Physical Exam
  - Often this is all you get.
  - Objective data:
    - Respiratory rate (RR)
      - This typically means resting respiratory rate
      - Typically more than 50 at rest is a concern
    - Gum color
      - Normal pink to red
      - Cyanosis
        - Bluish to red-purple gums
        - Do not see until SpO2 73%
        - Cyanosis requires immediate action.
Initial Diagnostics

- Physical Examination
  - Objective data
    - Temperature
      - Can help you determine the source of dyspnea.
      - Elevated temperatures are typically indicative of infectious or obstructive causes.
    - Heart Rate
      - Less reliable but can also help you determine the source of dyspnea.
      - In dogs CHF usually has an elevated heart rate.
Initial Diagnostics

- **Physical Exam**
  - **Subjective:**
    - Respiratory effort (RE)
      - When the work of breathing increases
      - Very subjective
    - Respiratory pattern
      - Chest and abdominal wall movement
      - They should be synchronous
      - When the thoracic wall expands, the abdominal wall should expand
      - Use of secondary muscles of breathing.
    - Stridor
    - Thoracic auscultation
      - Crackles
      - Wheezes
      - Murmur?
      - Arrhythmia?
    - Diminished heart and/or lung sounds
Initial Diagnostics

● Radiographs
  – Radiographs are indicated for all dyspneic patients
  – Should only be obtained when patient is stable for handling
  – Oxygen should be available in radiology
  – DV radiographs are preferred to limit stress and does not further impair respiration
  – Wait until sedation is in effect
Initial Diagnostics

- Pulse oximetry
  - Simple
  - Fast
  - Non-invasive
  - Works by passing 2 wavelengths of light through a thin part of the body. The machine recognizes and registers pulsatile flow. A ratio of oxygenated hemoglobin to deoxygenated hemoglobin is determined.
Initial Diagnostics

- Pulse Oximetry
  - Erroneously low readings may be caused by:
    - Hypoperfusion of the extremity
    - Incorrect sensor application
    - Highly calloused skin
    - Movement such as shivering
    - Pigment
  - Erroneously high readings
    - Carbon monoxide = 100%
    - Cyanide poisoning
    - Methemoglobinemia = 80%
Pulse Oximetry

SpO2 to PaO2

King LG, Respiratory disease of the Dog and Cat
Pulse Oximetry

Sites to obtain readings

- Anywhere there are arteries
  - Tongue
    - Usually have to be under sedation or anesthetized.
  - Lip
  - Toe
    - Hard to keep pet still
    - Can have pigment issues
  - Pinna
  - Vulva/Prepuce
  - Skin fold
Initial Diagnostics

- Arterial Blood Gas
  - Gold standard for oxygenation.
  - Specialized laboratory equipment required.
  - Samples
    - Obtained from artery
      - Dorsal pedal artery
      - Femoral artery
      - Lingual artery
Blood Gas

- Heparinized syringe
- Sample must be run quickly to prevent equilibration of atmospheric gas with sample
  - CO₂ will go down
  - O₂ will go up
- Normal on room air (21% oxygen) is 100mm Hg.
  - In the normal animal you can multiply the % oxygen inspired by 5 and PaO₂ should be near this calculated value.
- Goal is to have a PaO₂ of >60 mm Hg and a PaCO₂ <60 mm Hg
Blood Gas

- Venous
  - Viable option
  - Metabolic activity may alter findings
  - This sample is easier to obtain though a central venous sample is preferred
  - Goal is a $\text{PvO}_2 > 50$ and $\text{PvO}_2 < 60$
  - There is no easy way to predict the $\text{PvO}_2$
Initial Diagnostics

- **Thoracic ultrasound**
  - Quick way to see if pleural space disease is your underlying condition.

- **Diagnostic thoracocentesis**
  - If you have a high index of suspicion in an unstable patient, a blind centesis is indicated
  - Healthy lung will not be injured by a small needle puncture
The amount of oxygen needed depends on patient requirements. Ideally you are aiming for a PaO$_2$ > 60 mmHg or SpO$_2$ > 93% with a reduced work of breathing.

Prolonged periods of oxygen >60% can lead to oxygen toxicity and permanent pulmonary parenchymal damage
- 100% for 24 to 72 hours is lethal.
- 80% for 24 hours causes clinical changes but patients can survive.
Ongoing Oxygen Therapy

- Environmental cages
  - Pros
    - Can control % oxygen inspired
    - Isolates potentially infectious disease
    - Some control temperature and humidity
    - Some scrub carbon dioxide
  - Cons
    - They take a long time to get to prescribed oxygen concentration
    - Oxygen drops when you go into the cage
    - Some do not control for carbon dioxide, humidity or temperature
Ongoing Oxygen therapy
Ongoing Oxygen Therapy

- Elizabethan Collar/Hood oxygen
  - A snug e-collar is placed.
  - The opening is covered with cling wrap.
  - Oxygen is fed in through the neck
  - Flow rates of 0.75 to 1 LPM should maintain oxygen around 40%
Ongoing Oxygen therapy

- Nasal Oxygen
  - Good for long term therapy
  - More useful in larger patients
  - Flow rates between 50 and 100ml/kg/min should produce 40 – 50% tracheal oxygen
Ongoing Oxygen Therapy

- Nasal Oxygen
  - Sedation is required in all but debilitated patients
  - Topical anesthetic (lidocaine or proparacaine) instilled into the nares
  - A red rubber catheter (5Fr to 10Fr) is measured from the medial canthus to the nares. Additional fenestrations are made to prevent jet lesions
Ongoing Oxygen Therapy

- Nasal Oxygen
  - The catheter is reflected through the alar fold and secured to patient.
Ongoing Oxygen Therapy

Ongoing Oxygen Therapy

- **Nasal oxygen**
  - You do not want to exceed 3 to 4 LPM oxygen per nares or you may get jet lesions.
  - You want the shortest, widest catheter possible.
  - Oxygen should be humidified

- **Nasal prongs**
  - These only work in very sick/debilitated or highly sedated patients.
Ongoing Oxygen Therapy

- **Positive pressure ventilation**
  - Hypoxia despite conventional therapy
    - PaO$_2$ of less than 70mmHg on supplemental O$_2$
    - SpO$_2$ of less than 92%
  - Hypoventilation
    - PaCO$_2$ of greater than 60 mmHg
  - Excessive Respiratory Effort
    - Patients can maintain PaO$_2$ and PaCO$_2$ but the effort required to maintain this status will lead to respiratory failure.
Ongoing Oxygen Therapy

- Positive pressure ventilation
  - The average patient ventilated for pulmonary disease is on the ventilator for 3 to 7 days
  - CHF patients may be on from 12 to 72 hours
  - Patients ventilated for neuromuscular disease may be on for less than 24 hours, or up to several weeks depending on the disease condition.
Ongoing Oxygen Therapy

- Positive pressure ventilation
  - Without any other underlying disease condition:
    - Neuromuscular disease patients have about a 50% chance of coming off the ventilator and being discharged.
    - Pulmonary disease patients have a 25% chance of coming off the ventilator and being discharged.
      - Pneumonia patients typically do worse than edema or contusion patients.
Specific Situations

- **Crackles**
  - Either edema (CHF vs non-cardiogenic), pneumonia, or contusion.
  - Guides
    - Hx of trauma - contusion
    - Heart rate – if not tachycardic and no history of trauma, then probably pneumonia or contusions.
      - Exception – CATS!
    - Cat – odds are heart failure
      - Cats rarely get pneumonia
  - If in doubt give furosemide 2mg/kg IM and keep oxygen going until you can get additional diagnostics.
    - Radiographs, blood work, etc.
Specific Situations

- **Stridor**
  - Upper airway obstruction
    - Inspiratory dyspnea.
    - Laryngeal paralysis
    - Neoplasia
    - FB
    - Allergic reaction
  - SEDATE!
  - Intubate if needed
    - Do an airway exam if possible
Specific Situations

- **Stridor**
  - **Intubate**
    - You may have to keep them intubated until definitive correction can be obtained.
    - Clients should be warned that if there is a mass, it is very difficult to wake patient without tracheostomy in place.
Maintenance Anesthesia

- **Inhalant Anesthesia**
- **Injectable**
  - Propofol CRI 100 mcg/kg/min
    - Each cc provides 1.1 kcal and 0.1g of fat.
    - Propofol 28 is not recommended for this use due the benzyl alcohol.
  - Midazolam/Diazepam 0.1 – 0.4 mg/kg/hr
  - Fentanyl 7 – 20 mcg/kg/hr
    - Will need higher dosages after 4 – 6 days
  - Pentobarbital 1 – 3 mg/kg/hr
    - If used for more than 72 hrs, must start phenobarbital 24 hours before discontinuing to prevent seizure activity.
    - Expensive and hard to get
    - DO NOT USE EUTHANASIA SOLUTION
  - Ketamine 0.5 – 3 mg/kg/hr
    - Has opioid sparing effect and delays onset of tolerance
  - α-2 agonists 0.3 – mcg/kg/hr
    - Not recommended for critically ill patients due to cardiovascular changes.

- **Titrate to effect**
- **Multi-modal is usually ideal**
Specific Situations

- Collapsing trachea
  - Sedate
    - Butorphanol
    - Hydrocodone
  - Supplemental oxygen
  - Intubate as a last resort!
Specific Situations

- **Pleural space disease**
  - Animals with pleural space disease may present with a restrictive respiratory pattern.
    - Inward movement of the abdomen during inspiration
    - Thoracocentesis indicated if patient is dyspneic.
    - Even if coagulopathic.
    - Recurrent pneumothorax requires thoracostomy tube.
**Thoracostomy tube**

- Anesthetize
- Intubate
  - Clip and prep lateral thorax
  - Incision at 10th intercostal space
  - Tube will enter at 7th or 8th intercostal space.
Specific situations

- **Anemia**
  - This is a blood problem
  - No amount of oxygen short of hyperbaric oxygen therapy is going to help.
    - Oxygen is not going to hurt
  - IV fluids will increase profusion so are usually indicated.
  - Transfusion is indicated if pet is tachypneic, tachycardic, or showing signs of hypoxia
Specific Situations

- **Non-cardiogenic pulmonary edema**
  - Secondary to seizures, choking, near drowning, electrocution, etc.
  - Supportive care and time.
  - Prevent additional insults.

- **Near drowning**
  - Salt water better than fresh.
  - Treatment – supportive care and time.
Specific treatments

- Pneumonia
  - Supplemental oxygen as needed
  - Antibiotics – broad spectrum is usually the first choice.
  - Nebulization and coupage
  - Repeat radiographs q48h to discharge.
  - Supportive care.
Transfer

- These patients should be monitored 24 hours a day until non-oxygen dependent for 24 hours.
- Thoracocentesis prior to transport.
- If you elect to transfer to another facility, transport services should be considered.
  - Your staff should not transfer due to liability assumed if your staff member is driving
  - Client transfer is not ideal but is the second best option