Up 2 Date

Gas Law's

By Brian Sager

Introduction: As Air Medical providers we face changing physiological conditions regularly. Several questions should come to mind when you are preparing your patient for transport. What condition's and limitations inherent in air transport will affect my patient, crew, and equipment. Normal physiologic conditions occur up to 12,500 feet. The impact that altitude and flight physiology can impose can endanger both our patients and crewmembers.

Gas Laws

Boyles Law-In general terms as altitude increases gas expands. As we decrease altitude gas will contract. This also holds true for gas located within a closed space.

Any piece of equipment or body cavity containing gas will be subject to the effects of gas expansion and contraction.

Examples of conditions that are directly affected by Boyles Law:

Barotitis media- occurs with descent, trapped gas that affects the middle ear and can be very painful.

Barosinusitis- gas within the sinus cavity expands with ascent. Pain can occur during ascent or descent. Crew members should self evaluate prior to accepting a flight when sinus congestion is present.

Treatment for both: Slow your descent and/or ascend, Valsalva maneuver, vasoconstrictor spray, BVM.

Barodontalgia- gas expansion within an air pocket in the teeth. Commonly occurs during ascent

Treatment: descend altitude

Gastrointestinal distension, obstruction and other conditions: involves increased air trapping

Treatment: OG/NG tube and message abdomen

Other considerations for air transport:

ET tube cuff -air will expand with increase in altitude. Use manometer to measure ETT cuff pressures or consider using water or saline in lue of air in the cuff.

Consider Foley catheter, as there will be less room for the bladder to expand

Pneumothorax- commonly chest tubes will be placed with pneumothoraces 20% or greater with significant change in altitude

Air splints will expand with ascent and contract with descent. Keep close check on distal pulses and sensation during ascent and add air as needed while descending to prevent instability.

Pressurized IV bags can alter readings on pressurized line (i.e. CVP, Arterial line).

Volume cycled ventilators vs pressure – cycled ventilator. Pressure cycled ventilators are much less affected with increases in altitude. Monitor both delivered and exhaled tidal volumes.

Dalton's law: States, "the overall pressure of a gas mixture is the sum of the individual or partial pressure of all the gases in a mixture". Easier terms: regardless of altitude oxygen is present at 21% but decreased barometric (atmospheric) pressure causes less drive for oxygen to enter the lungs and capillaries. "Thin Air" causes hypoxia. Clinical studies show that patients have up to a 35% decrease in PaO2 6000-7500ft.

Treatment: Check your pulse ox next time you cross the divide you will be surprised. We should be wearing O2 per FAA Regulations:

(Table 2) **Federal Aviation Regulations and Oxygen Use**
Part 135 Operating Requirements: Commuter and On Demand Operations and Rules Governing Persons On Board Such Aircraft **Section 135.89 Pilot requirements: Use of Oxygen**
(a) Unpressurized aircraft. Each pilot of an unpressurized aircraft shall use oxygen continuously when flying— (1) At altitude above 10,000 feet through 12,000' MSL for that part of the flight at those altitudes that is of more than 30 minutes duration; and (2) Above 12,000 feet MSL.

Studies show degradation in night vision acuity with the lack of oxygen, over time.

Henry's Law: Evolved gas disorders or decompression sickness are the conditions that arise from the evolution of gas bubbles (primarily nitrogen) when barometric pressure decreases rapidly. Decompression sickness is more prominent in the elderly, patient's with excess body fat, and preexisting conditions. Symptoms that may occur are Bends, Chokes, Paresthesia's, & central nervous system disorders. These conditions involve the excessive buildup of nitrogen within their respective systems. With frequent exposure to altitudes greater than 18,000 feet- patients may show signs and symptoms.

Treatment: Descend to the lowest possible altitude. Place the patient on 100% oxygen via NRB, as this should eliminate any further nitrogen uptake and it will remove excess nitrogen from the system. Immobilize the affected area to prevent the nitrogen bubbles from migrating.

Considerations: Obese patients are at increased risk for developing fat emboli, and should breath 100% oxygen for 15 minutes prior to flight to reduce the risk.

References

1-Air and Surface Transport Nurses Association. (2010). *Transport nurse advanced trauma course* (5th ed.). Greenwood Village, CO: Author

2-Holleran, R. S. (Ed.). (2003). *Air and surface patient transport: Principles and practice* (3rd ed.). St. Louis, MO: Mosby.