



Chapter 191 – Air Medical Transport

Key concepts

- Boyle's law and Dalton's law have the greatest impact and explain the development of hypoxia and most common altitude-related symptoms. Other stresses of flight that can affect the patient or crew include temperature fluctuations, dehydration, noise, and vibration.
- Although most flight programs do both primary (scene flights) and secondary (interfacility) response, ground ambulance remains the primary means of out-of-hospital and interfacility patient transport.
- The helicopter offers several advantages over other transport vehicles, including reducing travel time by up to 75%, ability to avoid common ground delays (traffic, obstacles,) and ability to fly into locations that may be inaccessible to other modes of travel.
- All air medical services require involvement of a medical director responsible for supervising, evaluating, and ensuring the quality of medical care.
- As a general rule, helicopters are less useful in urban settings because of the proximity of health care facilities and a lack of open and safe landing zones.
- Helicopter emergency medical service (HEMS) represents the only modality by which nearly 28% of American residents have timely (within 1 hour) access to level I or level II trauma centers, and the research supports an improvement in trauma survival rates compared to ground transport.
- HEMS may benefit in other time-critical situations, including ST-elevation myocardial infarction (STEMI) patients going to a catheterization laboratory and acute stroke patients going to regional stroke centers.
- Safety is the predominant concern of air medical operations. The practice of a requesting EMS agency or hospital calling numerous HEMS programs after other programs have declined the flight because of bad weather, must be avoided.
- Essential considerations for landing zone safety are as follows: vehicles and personnel should be kept at least 100 ft from the landing zone; spectators should be kept at least 200 ft from the landing zone; helicopters should only be approached when signalled to do so by the pilot or an onboard crew member; never approach or depart from the rear of the helicopter; and if the aircraft is parked on a slope, approach and depart on the downhill side (greatest clearance under the blades).

Core questions

1. List 6 criteria for air medical transport
 - a. When should/could helicopter EMS transport be beneficial?
2. List advantages and disadvantages of rotor-wing aircraft and fixed-wing aircraft, relating to each other and land-transfer.
3. What are 6 principles of landing zone safety?

Wisecracks

1. What are the most common in-flight emergencies on commercial flights?
2. What are some practical implications of providing in-flight emergency care?



Rosen's In Perspective

Let's quickly recap a few gas laws. Because they are easy to forget and second, they apply to air medical transport!

GAS LAW	PRINCIPLE	CLINICAL IMPLICATION
Boyle's law	<p>The volume of a unit of gas is inversely proportional to its pressure.</p> <p>As altitude increases and atmospheric pressure decreases, the molecules of gas grow apart, and the volume of gas expands.</p> <p>With descent (increasing atmospheric pressure), the molecules are condensed, and gas volumes contract.</p> <p>The result is the expansion and contraction of gases within the closed spaces of the body.</p>	<p>Squeeze injuries from contraction of air and associated soft tissues can occur on descent, resulting in barotitis, barosinusitis, and toothache.</p> <p>Reverse squeeze injuries occur on ascent, leading to an increased volume of the air trapped within the space. Examples include the conversion of a simple pneumothorax into a tension pneumothorax and rupture of a hollow viscus.</p> <p>Medical equipment containing closed air spaces, such as IV tubing and pumps, air splints, ventilators, and endotracheal tube and laryngeal airway cuffs, may also be affected by altitude.</p> <p>Responsible in part for hypoxia at altitude due to fewer molecules of oxygen present per volume of inhaled gas.</p>
Charles' law	<p>As the volume of a unit of gas rises, the temperature of that volume falls.</p>	<p>Explains why the ambient temperature decreases with increased altitude.</p>
Dalton's law	<p>The total barometric pressure at any given altitude equals the sum of the partial pressures of gases in the mixture.</p> <p>Oxygen still constitutes 21% of the atmospheric pressure at altitude.</p>	<p>A decrease in arterial oxygen tension with increasing altitude, resulting in hypoxia. Initial physiologic responses to hypoxia include tachypnea and tachycardia.</p> <p>Initial physiologic responses to hypoxia include tachypnea and tachycardia.</p> <p>With prolonged exposure, cerebral hypoxia causes headache, nausea, drowsiness, fatigue, unconsciousness, and death.</p>
Henry's law	<p>The mass of gas absorbed by a liquid is directly proportional to the partial pressure of the gas above the liquid.</p>	<p>Sudden decompression at altitude may result in dysbaric injuries.</p> <p>In scuba diving, rapid ascent can result in gas to come out of solution within the bloodstream, resulting in decompression sickness.</p>

From Rosen's table 191.1



What are four potential body cavities affected by Boyle's law?

This law has to do with the effects of gases in an enclosed space.

- Middle and inner ear
- Sinuses
- Teeth
- Alveoli or blebs
- Bowels

Let's jump into the facts for today! (If you want the historical perspective and current trends check out the chapter!)

Core questions

1) List 6 criteria for air medical transport

- Although virtually all types of patients have been transported by air medical services, available data do not allow prospective, identification of which patients will benefit from flight.
- The data is controversial and limited; but here are a few situations where flight may make a difference:
 - *an estimated 20% to 35% improvement in survival rates compared to ground transport, or the saving of three to six lives (fewer for pediatric patients) per 100 air medical trauma flights.*
 - *Based on time savings alone then, a conservative estimate suggests that properly used HEMS can save one to two lives per 100 STEMI missions.*
 - Possibly patients with stroke who are candidates for reperfusion
 - Transportation of critically ill neonates and children

Box 191.3 Criteria for Air Medical Transport

- **Distance** to the closest appropriate facility is too great for safe and timely transport by ground ambulance.
- **Patient's clinical condition** requires that the time spent in transport be as short as possible.
- Patient's condition is **time critical**, requiring specific or timely treatment not available at the referring hospital.
- Potential for **transport delay** associated with ground transport is likely to worsen the patient's clinical condition.
- Patient requires critical care life support during transport that was not available from the local ground ambulance service.
- Patient is located in an area **inaccessible** to regular ground traffic, impeding ambulance egress or access.
- Local ground units are not available for long-distance transport.
- Use of local ground transport services would leave the local area without adequate EMS coverage.
- For **interfacility medical transport**, the requesting physician based on his/her best medical judgment and information available at that time of transport determined the need for AMT.
- For scene medical transport, the requesting authorized out-of-hospital provider based on applicable policy, his/her best medical judgment and information available at that time of transport determined the need for AMT.



a. **When should/could helicopter EMS transport be beneficial?**

- Distance
- Access
- Condition
- Critical Care or specialized
- Inter-facility Needs

2) **List advantages and disadvantages of rotor-wing aircraft and fixed-wing aircraft, relating to each other and land-transfer.**

Advantages of fixed wing	Advantages of rotary wing
<ul style="list-style-type: none"> • Faster for distances > 250 km • Greater distance range • Less noise • Climate controlled • Pressurized cabin • More room for procedures 	<ul style="list-style-type: none"> • Low flight ceiling • On scene landing • Hospital landing • Rapid transport over short distances (able to avoid traffic or geographic obstacles)
<ul style="list-style-type: none"> • Less expensive • Greater weight capacity • Greater physical space for equipment, multiple personnel 	<ul style="list-style-type: none"> • Noise • Vibration • Thermal variances • Stressors on patients and crew • Weather • Limited space

3) **What are 6 principles of landing zone safety?**

“Helicopter landing zones are inherently dangerous places. The most obvious risk of injury is impact with rotor blades. This danger is heightened during ground operations, because the blades dip lowest to the ground at the slower rotor speeds associated with engine start-up and shutdown. Injuries also may occur as a result of debris being propelled through the air by “rotor wash,” increased noise levels and an inability to hear warnings, and slippery surfaces found on exposed landing sites.”

- Rosen’s 9th edition, ch 191

- **Landing area**
 - 100 x 100 ft
 - Landing personnel > 100ft from landing zone
 - FLAT terrain
 - Free of debris
 - Well lit
- **Hazards**
 - Watch for buildings, powerlines, trees
 - Remove the area from any loose debris
 - No smoking within 50 ft of landing zone
- **Approach**
 - Path should point into the wind and be free of obstruction to an altitude of 500 ft above the surface.
 - Path should not pass over command posts, treatment areas, or operationally congested areas on the ground.
 - Clear indicator of wind direction
- **Communication**
 - Via radio or hand signals



Wisecracks

1) What are the most common in-flight emergencies on commercial flights?

The aircraft cabin is an environment with hypobaric hypoxia (pressurized to 1500-2500 m) and decreased air pressure.

People with fragile cardiopulmonary disease may develop health problems as their oxygen saturation levels decline (due to the steep oxyhemoglobin desaturation curve) - classic scenario is the patient with angina due to cardiac ischemia.

When it comes to the pressure changes, as you remember from Boyle's law people with air cavities in their body that can't be equalized may notice an up to 30% increase in gas volume at altitude. This is an issue in situations such as: pneumothoraces, inflated medical devices, etc.

Most diversions are caused by cardiac (e.g. cardiac ischemia), neurologic (seizures, or pulmonary (e.g. asthma or COPD exacerbation) emergencies. Exact incidence rates vary based on the studies, but here are a few estimates (from **Dr. Moore, 2017**):

- Syncope 10-35%
- Cardiac emergencies 16-23%
- GI symptoms 13-30%
- Respiratory emergencies 9-10%
- Trauma 4-13%
- Anxiety 5%
- Seizures 3%
- ENT 1-9%
- Allergies 1%
- Other 10%

Triggers

- Hypobaric hypoxia
- Pressure changes
- Exertion, dehydration of travel
- Prolonged sitting
- Medication nonadherence due to circadian rhythm disruption
- Unable to access medications in check bags
- ETOH use

- Want to learn more about this? Check out:
 - <https://www.iata.org/publications/Documents/medical-manual.pdf>
 - Uptodate: "Management of inflight medical events on commercial airlines"

2) What are some practical implications of providing in-flight emergency care?

Some of these implications vary based on the country you are in. For example, USA/Canada/UK have similar laws; whereas many countries in the European Union impose an obligation on physicians to render aid.

- a. Physician's ethical duty to care
 - i. Ethical duty (not necessarily legal)
- b. Medico-legal implications
- c. Good Samaritan legislation



- d. *The Samaritan is protected against malpractice litigation, if the following conditions are met:*
- *The Samaritan is medically qualified to perform the service*
 - *The Samaritan acts voluntarily*
 - *The Samaritan acts in good faith*
 - *The Samaritan does not engage in gross negligence or willful misconduct*
 - *The Samaritan receives no monetary compensation (seat upgrades and travel vouchers do not count as compensation)*

A few general recommendations from Uptodate:

- *Obtain passenger consent whenever possible.*
- *Use an interpreter if necessary and available.*
- *Ask whether ground-based medical support is available to help you, particularly if the situation falls beyond your medical specialty or skill set.*
- *Recommend diversion to the closest appropriate airport for any serious condition (remember that the captain is not obligated to follow your recommendation).*
- *Document the following in writing: history, examination, impression, treatment, and communication with crew and ground medical support.*
- *Be cautious with unfamiliar interventions.*
- *Do not accept or request financial compensation for any medical assistance provided. Some airlines will offer a token of gratitude, such as travel vouchers, seat upgrades, or credit for travel miles, and these may be accepted as a gift, but not as compensation.*
- *If you have ingested any alcohol or medications that may impair your alertness or judgement, it is best not to care for a sick or injured patient. An intoxicated or impaired medical provider is at risk of being categorized as engaging in "gross negligence and willful misconduct." As such, not only might you harm the patient, but you would not be covered under the AMAA Good Samaritan Law.*
- *Good Samaritan laws apply to in-flight medical emergencies. They do not apply to non-emergency medical advice that you may provide.*

From Uptodate