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Management of inflight medical events on commercial airlines

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INTRODUCTION

Inflight medical events are increasing due to the steadily rising number of air travelers, the aging of the United States and European populations, and the increasing mobility of people with acute and chronic illnesses [1,2]. Traveling physicians and other medical providers may suddenly find themselves in a difficult environment, in front of many onlookers, managing conditions they do not normally treat, with unfamiliar equipment. There are no universal guidelines for managing inflight medical events, but there are aspects of the aircraft environment and resources of which the treating clinician should be aware. This topic will review the following:

- Epidemiology of inflight medical events and emergencies
- Cabin environment and how this may affect passengers with medical complaints
- Airline medical emergency protocols
- Medical resources aboard aircraft (see 'Resources on board an aircraft' below)
- Management of common emergencies (see 'Common inflight medical emergencies and complaints' below)
- Liability and legal protection for Good Samaritans

Screening of patients for air travel is discussed separately.

- (See "Assessment of adult patients for air travel".)
- (See "Evaluation of patients for supplemental oxygen during air travel".)

EPIDEMIOLOGY

Worldwide air passenger numbers have continued to rise, exceeding 4.3 billion in 2018 [3]. Inflight medical events (IFMEs) have been reported to occur at a rate of approximately 15 to 100 per million passengers, with a death rate of 0.1 to 1 per million [4-8]. The precise incidence of IFMEs is unknown because there is no mandatory reporting system and no consistent or widely accepted definition of what constitutes an IFME. Flight crews do not routinely report minor inflight medical incidents that do not require ground-based medical support (GBMS) [1,9]. Given the rising numbers of travelers, it has been estimated that as many as 260 to 1420 IFMEs occur daily worldwide [10].

The advent of GBMS has substantially changed the way IFMEs are handled. GBMS is now used by most large international carriers and by virtually all United States based airlines. GBMS is usually provided by practicing emergency physicians who receive additional instruction about the aviation environment and operations. A medical event record is created each time a flight contacts GBMS. The threshold for using GBMS and the means of contact differ among airlines and over time. Variables include the communication capabilities of the aircraft (eg, radio only, satellite phone, specific telemedicine device) as well as the airline's culture.

One study found that 9 percent of inflight incidents prompted a call for GBMS advice [11], while a review of five major airlines reported that 11,920 calls for medical assistance were made over approximately three years, during which 744 million passengers traveled [7]. These data suggest that most IFMEs are not serious and are handled adequately by airline crews alone, as it is more likely that crewmembers would use GBMS for more serious events and true medical emergencies, unless that were not possible due to logistical obstacles (eg, immediate landing, communication black spots). Medical diversions (ie, premature landings for medical reasons) occur in approximately 4 percent of flights requiring assistance from GBMS [10].

A number of studies have attempted to examine airline emergencies in greater detail. Airport-based studies suggest an incidence of 16 to 25 emergencies per million passengers, which translates into approximately one medical emergency every 604 flights [5-7,12-14]. The fatality rate was approximately 0.1 to 0.3 deaths per million passengers. Other studies have examined all inflight events that occurred with a particular airline, or that generated a call from the airplane to GBMS. A few early studies of this type suggested that severe emergencies were increasing in number [5,7,9,15]. The Air France study, mentioned above, which covered the years from 1989 to 1999, noted that 35 percent of all calls recorded over the 10-year period were made in the final two years [16]. However, available data are limited and should be interpreted with caution. A medical professional is present for 40 to 70 percent of inflight medical emergencies, and a doctor is present in 30 to 60 percent [7,17-19]. These numbers may be higher; fear of liability prevents some clinicians from intervening [20]. (See 'Liability and legal protection for Good Samaritans' below.)

Two additional factors may be contributing to a rise in IFMEs: the proliferation of low-cost airlines and the growth of "medical tourism," which may involve individuals with severe illness travelling to obtain low cost, quality health care [21]. However, in general, the flying population mirrors the general population, and the incidence of serious medical events simply reflects the increased number of people participating in commercial air travel. Thus, the number of IFMEs will rise as the number of air travelers continues to increase, even if the relative rate of serious medical events remains unchanged.

Common medical complaints reported to airplane crews include:

- Neurologic, including syncope, dizziness, and seizure (see 'Neurologic events' below)
- Respiratory, including asthma exacerbation (see 'Respiratory events' below)
- Gastrointestinal, including abdominal pain, nausea, vomiting (see 'Gastrointestinal events' below)
- Cardiac, including chest pain (see 'Cardiac events' below)
- Traumatic (see 'Head injury and other trauma' below)
- Musculoskeletal

Neurologic, respiratory, and cardiac complaints comprise the most serious emergencies, as determined by aircraft diversion or the use of GBMS [1,6,7,16-18,22,23]. Among these, cardiac emergencies account for the highest rate of flight diversions and deaths [7,23,24]. Nearly all such cases involve adults.

Nevertheless, although obstetrical and pediatric emergencies during commercial air flights are rare, they do occur. According to one review, approximately 7500 IFMEs involving children aboard commercial airlines were reported to GBMS between 2010 and 2013 [25]. Ten cases (0.13 percent) resulted in death, and nine involved children under the age of 2 (median age of 3.5 months). Two children were noted to be travelling to receive care for a severe pre-existing medical condition. A subsequent review of 75,587 IFMEs requiring GBMS found that 11,719 (15.5 percent) involved children, of which the great majority resolved in flight; 16.5 percent required further medical care after landing; 14 percent involved infants; and 0.5 percent led to aircraft diversion [26]. The most common issues were nausea and vomiting (33.9 percent) and fever (22.2 percent).

CABIN ENVIRONMENT

Inflight medical events may be precipitated by the unique physiologic stresses of air travel, including the conditions within the aircraft cabin. These factors most often exacerbate a passenger's chronic disease, or elicit an existing but heretofore unrecognized medical condition. Rarely, they may cause a novel medical problem in cases of an injury or in-flight transmission of a communicable disease.

The contemporary in-flight cabin environment is extremely well-tolerated by otherwise healthy passengers, and it is unlikely that the cabin environment per se would cause a medical emergency in the absence of a significant pre-existing condition. One possible exception is injuries related to unexpected, severe turbulence.

Nevertheless, the cabin environment combined with other stresses from long-distance travel (eg, sleep deprivation, anxiety, disruption of medication schedule, transporting heavy luggage) may cause clinical decompensation in predisposed individuals. For patients with such predisposing conditions, appropriate assessment and education is important. (See "Assessment of adult patients for air travel" and "Approach to patients with heart disease who wish to travel by air or to high altitude" and "Pneumothorax and air travel" and "Evaluation of patients for supplemental oxygen during air travel" and "Prevention of venous thromboembolism in adult travelers".)

Reduced oxygen — Commercial aircraft are pressurized during flight because passengers could not survive the low atmospheric pressure at the usual cruising altitude, which is commonly maintained between 30,000 to 40,000 feet (approximately 9100 to 12,200 m). It is impractical to maintain cabin pressure at sea level pressure (by flying at lower altitudes) because of aircraft weight and fuel economy, as more fuel is needed when flying at lower altitudes [27]. In addition, there is a maximum pressure gradient the aircraft fuselage can sustain without damage due to the increased wall tension. Thus, the aircraft cabin typically is pressurized to the equivalent of approximately 4000 to 8000 feet (approximately 1400 to 2500 m) above sea level, and the United States Federal Aviation Administration (FAA) specifies that an 8000-foot environment be maintained even at the highest operating altitude (table 1) [28]. During shorter flights (<750 miles, or 1200 km), cabins are pressurized to the equivalent of lower altitudes. (See "Evaluation of patients for supplemental oxygen during air travel".)

Cabin pressure is a function of the aircraft's actual altitude, and is automatically set through the aircraft's environmental control system. Different generations and types of aircraft have different rates of pressurization and ascending profiles. As an example, if permitted by air traffic control, smaller, lighter aircraft reach cruising altitude faster than larger, heavier ones, which need to burn fuel, thereby decreasing their weight, before reaching maximum altitudes.

The barometric pressure inside the aircraft cabin drops from a normal sea level value of 760 mmHg to approximately 560 mmHg during flight. As a result, the PaO2 in normal individuals drops from a baseline of around 70 to 95 mmHg at sea level to a PaO2 of 50 to 60 mmHg inside a cabin pressurized at 8000 feet (2500 m) [29]. In one study, the oxygen saturations of healthy passengers were measured and showed a decline from 99 percent before takeoff to 94 percent during flight [30]. This drop in arterial blood oxygen saturation occurs along the flat portion of the oxyhemoglobin dissociation curve and is usually not noticeable to healthy adults at rest during a flight. (See "Measures of oxygenation and mechanisms of hypoxemia".)

Passengers may respond to this relatively hypoxic environment by increasing their heart rate, cardiac output, respiratory rate, and respiratory volume. Some may experience mild fatigue. However, in individuals with cardiopulmonary disease compensation can be insufficient. For them, a relatively small drop in oxygen saturation can occur on the steep part of the oxyhemoglobin dissociation curve, severely compromising their cardiopulmonary reserves and precipitating a medical emergency, such as cardiac ischemia or respiratory distress [2,29,31,32]. The relative hypoxia can also trigger complications in passengers with sickle cell disease. (See "Overview of the clinical manifestations of sickle cell disease".)

Reduced ambient pressure and potential complications — Boyle's Law (P x V = P' x V') explains how a set amount of air trapped in a container or hollow viscus will expand to occupy more space at a lower barometric pressure. The diminished air pressure during flight at 8000 feet (2500 m) can lead to the expansion of gas volume up to 30 percent compared with sea level [2,33]. A medical emergency can ensue if the expanding gas is constrained within a confined space such as the pleural cavity, the middle ear, sinuses, a medical device, or another body cavity after surgery [27].

Most passengers have experienced discomfort due to expanded air in the middle ear that develops when the aircraft climbs rapidly after takeoff to achieve cruising altitude or during descent prior to landing. Usually, such discomfort is self-limited as air spontaneously moves to or from the middle-ear via the Eustachian tube, re-equilibrating internal and external pressures across the tympanic membrane. Travelers can help equilibrate pressures by yawning or by performing a Frenzel or mild Valsalva maneuver. Chewing gum and frequent swallowing, or for infants a bottle or pacifier to suck on, during ascent and descent can limit discomfort [32].

Failure to equilibrate pressures in the middle ear (barotitis media) or paranasal sinuses (barosinusitis) can cause pain, tinnitus, vertigo, hearing loss, and rupture of the tympanic membrane. The change in barometric pressure can also cause a toothache (barodontalgia) in those with dental disease. (See "Ear barotrauma" and "Complications of SCUBA diving", section on 'Dental barotrauma'.)

Pneumothorax is a less common but more dangerous potential complication of changes in air pressure. Expansion of trapped gas in the lungs can cause a pneumothorax during flight, especially in individuals with chronic obstructive pulmonary disease (COPD), cystic fibrosis, or recent thoracic surgery. A small untreated pneumothorax can expand substantially at altitude. (See "Pneumothorax and air travel".)

Increased pressure can develop within hollow organs of the gastrointestinal tract and may cause abdominal distention, pain, and nausea. Expanding intestinal gas may cause dehiscence of surgical wounds, hemorrhage, or bowel perforation in air travelers with recent abdominal surgery complicated by ileus or those with small or large bowel obstruction. In addition, passengers with recent central nervous system or ophthalmologic surgery may be susceptible to problems associated with the expansion of trapped gas [2]. As an example, following retinal surgery gas is injected into the ocular globe, and sight-threatening complications may ensue from increased intraocular pressure should such gas expand to a sufficient degree [34,35].

Gas expansion can also affect medical devices with pneumatic components, for example, urinary catheters, feeding tubes, pneumatic splints, and the air-filled cuffs of tracheostomy tubes. Instilling saline solution or water instead of air may avert some problems [29]. However, tracheal tube cuff pressures can be difficult to manage, and it is likely best to check these during and following a flight [36,37]. Releasing air from inflatable devices may reduce overexpansion, which could cause local trauma or rupture [2,29]. Some insulin pumps may be susceptible to changes in delivery rate due to the expansion of small air bubbles within the device [38]. Left ventricular assist devices (LVADs) do not appear to be harmed by the cabin environment, although data are limited [39].

Air quality

Low cabin humidity — Cabin air is very dry, usually between 10 and 20 percent humidity; optimal humidity ranges from 40 to 70 percent [29,31]. Low humidity can dry the skin, corneas, and airway passages, triggering respiratory problems, especially in patients with asthma or COPD [2,40]. Insensible water loss in the desiccated cabin environment, combined with diminished fluid intake during a long flight, can cause discomfort but typically is not sufficient to cause clinically significant dehydration in an otherwise healthy adult. Low humidity can contribute to thick mucus in patients with tracheostomy tubes or transtracheal oxygen catheters [2].

Transmission of airborne pathogens — A commercial aircraft's air conditioning and ventilation system (using high-efficiency particulate air filters) is able to maintain low bacteria, fungi, and viral counts in the cabin. However, there are reports of individuals possibly contracting a number of infectious diseases through airborne transmission during commercial flights, including tuberculosis, influenza, measles, smallpox, and severe acute respiratory syndrome (SARS) [29,41-43]. Risk of infection appears to be greatest on flights longer than eight hours and among passengers seated within two rows of the infected passenger [29]. Nevertheless, some reports describe possible in-flight transmission during SARS epidemics to passengers seated far from the index passenger [43]. It is possible that transmission may have occurred before or after the flight when passengers may be close to one other while on line for boarding, using the bathroom, or awaiting security or immigration checks. Rarely, if ever, do such infections create acute management problems during flight, as the incubation period is longer than the duration of the trip. (See 'Infectious disease' below.)

General environmental factors — Aside from cabin air, the general environment of an aircraft during flight can contribute to a number of medical issues. Airplanes are noisy and subject passengers to significant vibration and turbulence. Turbulence in turn can precipitate motion sickness, and falling overhead items can cause significant head trauma and other injuries [17]. Traveling long distances disturbs circadian rhythms and possibly disrupts patients' medication schedules. Food poisoning can occur during flight or symptoms may begin in-flight. (See "Initial management of trauma in adults" and "Initial evaluation and management of facial trauma in adults" and "Skull fractures in adults" and "Travelers' diarrhea: Epidemiology, microbiology, clinical manifestations, and diagnosis".)

Prolonged immobility in a seated position increases the risk for venous thromboembolism (VTE) during air travel, although some studies report that obesity, extremes of height, use of oral contraceptives, and coagulopathies are more likely to account for air travel-related VTE [44,45]. Of note, observational studies of healthy volunteers performed in hypobaric chambers fail to demonstrate an association between hypobaric hypoxia (of a degree that might be encountered during commercial air travel) and prothrombotic alterations in the blood [46]. (See "Overview of the causes of venous thrombosis" and "Prevention of venous thromboembolism in adult travelers".)

AIRLINE PROTOCOLS FOR MANAGING MEDICAL EMERGENCIES

Each airline follows its own protocol for managing an inflight medical emergency, and each event is handled on a case-by-case basis. In general, such emergencies are addressed in the following manner [16,29]:

- Cabin crew is notified of a possible medical emergency and makes an initial assessment of the situation.
- Captain is informed of the situation.
- Crew solicits assistance from on-board medical professionals as needed.
- Captain calls for ground-based medical support (GBMS) as needed.
- Based on assessment of passenger's condition, the captain determines course of action, which may include:
  - No change in flight plan, but request for medical personnel to meet the flight upon arrival
  - Expedited landing at intended destination
  - Diversion to a closer location

Regardless of the source of medical support, the captain remains the ultimate decision maker for any commercial aircraft under all circumstances. Any medical advice, whether from ground or on-board medical professionals, is exactly that — advice. In making decisions, the captain must consider a host of factors, including weather conditions, turbulence, air traffic, approach charts, runway length, landing weight of the airplane, and proximity to appropriate ground medical facilities. Even under ideal conditions, the captain and crew require at least 20 minutes to land an aircraft.

The role of the volunteer medical professional is to assist the flight crew with the medical problem, not to take control. Ideally, the clinician and GBMS personnel work together to manage problems. GBMS staff are knowledgeable about the resources available to manage inflight emergencies and can make informed recommendations about aircraft diversion [29]. However, such interactions may of necessity be indirect, as it is not always possible to establish direct communications in aircraft where communication lines are limited to the cockpit, to which access is restricted out of security concerns. In some airlines, ground communication is available in the passenger cabin. Using GBMS frequently alleviates the pressure felt by a volunteer clinician trying to manage a passenger in unfamiliar and sometimes difficult circumstances.

Many inflight medical problems are relatively minor, and do not require major interventions or changes in the flight plan. In addition, GBMS is available for virtually all major United States airlines and most international airlines.

RESOURCES ON BOARD AN AIRCRAFT

The International Civil Aviation Organization (ICAO) is the United Nations agency in charge of standards and recommended practices for commercial aviation. The ICAO calls for three types of medical kits:

- First Aid Kit (FAK) – The number of FAKs required is proportional to the number of seats in the aircraft. The standard ratio is one FAK for every 100 seats. Although the contents of the FAK are primarily for wound care, some countries include non-prescription medications as well.
- Emergency Medical Kit (EMK) –The recommended practice of the ICAO is for aircraft authorized to transport more than 100 passengers for flights over two hours to carry a medical kit for the use of medical doctors or other qualified persons in treating in-flight medical emergencies. The EMK contains medications and is opened under the responsibility of a qualified health care practitioner.
- Universal Precaution Kit (UPK) – The UPK contains personal protection equipment for crew members and volunteer health professionals who may be exposed to a communicable disease.

The medications listed by ICAO for inclusion in the EMK are not standard or recommended practice, but guidelines only. Each ICAO member state may regulate the contents of the EMK. In addition, individual airlines are at liberty to enhance the medical resources available on their aircraft. As a result, there is significant variation in the content of medical kits across the airline industry worldwide [47].

According to the United States Federal Aviation Administration (FAA): "Flight attendants should grant access to the equipment only to trained crewmembers or to other persons qualified and trained in the use of emergency medical equipment. The decision to allow passengers to assist another passenger and have access to medical equipment is up to the air carrier and its agents." The FAA does not define the various medical specialties because this might deny access to the only person available to assist with a medical emergency.

The European Aviation Safety Agency (EASA) states that the captain should control access to the EMK. Drugs should be administered by medical doctors, qualified nurses and physician assistants, paramedics, emergency medical technicians, or other qualified health care practitioners. However, medical students, paramedic students, emergency medical technician students, and nurse aids may administer drugs if no other qualified health care professional is aboard the flight and appropriate advice has been received from GBMS. Even so, according to EASA, oral medications should not be denied in medical emergencies even if no medically qualified persons are present.

The FAA requires passenger-carrying aircraft weighing more than 7500 pounds (3400 kg) maximum capacity with at least one flight attendant to carry an enhanced EMK with specified contents. This is in addition to a basic first aid kit, which contains bandages, compresses, antiseptic swabs, arm and leg splints, tape and scissors, and ammonia inhalants [2,48]. The required EMK contents include:

Medications

- Aspirin tablets: 325 mg
- Antihistamine (diphenhydramine) tablets: 25 mg
- Antihistamine (diphenhydramine), 50 mg injectable single dose
- Atropine: 0.5 mg, single 5 mL
- Dextrose 50%/50 mL injectable
- Epinephrine 1 mg/mL for intramuscular (IM) injection – for allergic emergencies
- Epinephrine 1 mg/10 mL for intravenous (IV)/intraosseous (IO)/endotracheal (ET) use – for cardiac arrest
- Inhaled bronchodilator (metered dose or equivalent)
- Lidocaine: 5 mL, 20 mg/mL
- Nitroglycerin tablets: 0.4 mg
- Non-narcotic analgesic
- Saline solution, 500 mL
- Instructions for medications

Equipment

- Automated external defibrillator
- Sphygmomanometer
- Stethoscope
- Oropharyngeal airways
- Latex gloves or equivalent
- Syringes
- Needles
- IV administration kit with tubing and connectors
- Self-inflating manual resuscitation device (AMBU bag) with masks (three sizes)
- Cardiopulmonary resuscitation (CPR) masks (three sizes)

Some United States airlines have enhanced EMKs containing additional cardiac medications and equipment. Common additions include epinephrine auto-injectors, glucagon, and naloxone. Ondansetron in its oral dissolving form is becoming a common addition. Some airlines include pediatric preparations of analgesic and anti-histaminic drugs. Injectable diazepam, primarily intended for treatment of seizures, is a mandatory item for European carriers, but not in the United States.

A list of EMK medications and equipment recommended by the Air Transport Medicine Committee of the Aerospace Medical Association is provided (table 2) [49,50]. Ampules of epinephrine 1 mg/mL were previously labeled as 1:1000, and ampules of epinephrine 1 mg/10 mL were previously labeled as 1:10000, but to help prevent medication errors, ratio expressions were removed from epinephrine labels in the United States in 2016.

Resources for pediatric and obstetrical emergencies — The FAA requires a pediatric size oral airway, and a CPR mask and bag-valve mask of pediatric size. However, infant size equipment is not required and is unlikely to be available. Specific pediatric medications, such as 10% dextrose IV solution, are not required, and it is unclear whether the medication information cards included with the EMK include pediatric dosages, or if IV catheters sized for small children and infants are available. No specific equipment or medications for obstetrical emergencies are included in the EMK, including a bulb suction device.

Automated external defibrillator — Most countries do not require that commercial aircraft carry automated external defibrillators (AED), but most large international carriers do, and the FAA requires them on domestic aircraft [2]. A large proportion of episodes of sudden cardiac arrest in out-of-hospital public settings are caused by ventricular fibrillation (VF). VF can only be treated effectively with defibrillation, and time is critical [51]. (See "Advanced cardiac life support (ACLS) in adults".)

Some models of AEDs can be used for cardiac monitoring in addition to defibrillation. In one report of inflight AED use, the device was used in 40 of 169 cases to treat cardiac arrest with the remainder for cardiac monitoring [52]. AED performance during flight conditions should be considered when selecting a model for purchase. Some AEDs designed for ground use were found not to perform well during simulated ground taxi vibration and in-flight turbulence [53]. (See "Automated external defibrillators".)

Large prospective observational studies have shown that defibrillation with an AED substantially improves the chances of survival to discharge compared with CPR alone. If a cardiac arrest occurs during flight, at least 20 minutes will pass until defibrillation is possible, unless AEDs are available aboard the aircraft. An observational study that examined the use of AEDs in one airline over two years found that AEDs successfully shocked 13 of 14 patients in VF, of whom 40 percent survived to hospital discharge. Another study documented defibrillation in 9 of 10 patients whose initial rhythm was VF or unstable ventricular tachycardia, of whom five survived [52]. Another research group extrapolated arrest and resuscitation rates to worldwide air travel and estimated that of the 452 passengers who would sustain VF arrests inflight, 93 would live (21 percent) if an AED were available and used appropriately [54]. The epidemiology of sudden cardiac arrest and other aspects of AED allocation and efficacy are discussed separately. (See "Prognosis and outcomes following sudden cardiac arrest in adults" and "Automated external defibrillators".)

Oxygen — Supplemental oxygen is available for inflight medical emergencies but often is limited to flow rates between 2 and 4 L per minute. Most air carriers will provide oxygen for a fee to passengers with stable medical conditions who require low-flow oxygen. Guidance about traveling with oxygen is provided separately. (See "Evaluation of patients for supplemental oxygen during air travel".)

Portable oxygen concentrators (POC) are permitted on board commercial aircraft. The FAA keeps a list of approved devices, which can be found here. Passengers traveling with a POC should be advised that the demand for oxygen is higher inflight due to the lower oxygen pressure within the cabin. Therefore, a higher flow rate is needed for the POC. Not every flight makes electric outlets available so it is prudent for the patient to bring an appropriate number of spare batteries based on travel plans, including reserves in the case of unforeseen delays.

Crew — All crew members are required to be trained in the operation of the emergency medical equipment available on board. Flight attendants receive recurrent training in first aid and basic life support, with the FAA requiring CPR and AED training every 24 months. They may also be trained in their airline's protocols for various emergencies, but they are not required to meet the proficiency standards established for emergency medical personnel [1].

Passengers — Other travelers may have medical skills and be able to assist if requested. Passengers, both the sick individual and others aboard, may be carrying medications (eg, benzodiazepine) or equipment (eg, glucometer) not included in the emergency kit that may be helpful in an emergency.

Ground-based medical support (GBMS) — The GBMS available to commercial aircraft generally takes one of three possible forms. Most airlines contract with a third party that provides physician access [2,4]. In a few countries (eg, France), ground support is offered through the public health system to the country's commercial airlines. Finally, a few airlines employ physicians who are available by radio or telephone to help with emergencies [5,16].

However, this model has become less common, and has virtually disappeared in the United States. In all situations, the physicians available have training and experience in emergency medicine, aviation physiology, understand the resources available and the constraints involved in managing medical conditions during flight, and can advise the flight crew or a physician passenger.

COMMON INFLIGHT MEDICAL EMERGENCIES AND COMPLAINTS

The most common serious inflight medical emergencies that lead to diversions result from cardiac, neurologic, and pulmonary disease [1,7,17,29,48].

Cardiac events

Common complaints and available resources — The chief cardiac complaint among aircraft passengers is typically chest discomfort or angina.

Assessment of the patient with chest discomfort is discussed separately. (See "Evaluation of the adult with chest pain in the emergency department" and "Initial evaluation and management of suspected acute coronary syndrome (myocardial infarction, unstable angina) in the emergency department".)

Management of common cardiac emergencies is reviewed separately. (See "Advanced cardiac life support (ACLS) in adults" and "Adult basic life support (BLS) for health care providers" and "Initial evaluation and management of suspected acute coronary syndrome (myocardial infarction, unstable angina) in the emergency department" and "Overview of the acute management of non-ST-elevation acute coronary syndromes".)

Cardiac complaints comprise about 10 to 30 percent of inflight medical events (IFMEs), and in most studies, they are the most common cause of aircraft diversion (about 20 to 46 percent) and passenger death (more than 60 percent) [5-7,13,17,18,55,56]. One observational study found that of 40 passengers subsequently admitted to an intensive care unit (ICU) following an inflight medical emergency, 27 were for cardiac causes [1,5,18,55,56]. Triggers include the low cabin oxygen pressure, the exertion of travel, and medicine noncompliance due to circadian disruption or lack of access to medications in checked baggage.

Diagnostic tools available aboard aircraft include a stethoscope and a sphygmomanometer. However, regardless of the quality of the device, stethoscopes are generally of limited use for auscultating the heart during flight due to the background noise of the engines. A health care practitioner can attempt to measure the blood pressure with a sphygmomanometer but may be forced to approximate the blood pressure using palpation, although the accuracy of this method is limited.

Some international aircraft have electronic blood pressure cuffs, pulse oximeters, and glucometers in their emergency medical kits (EMKs), and some carry advanced automated external defibrillators (AEDs) with a screen that can be used to determine the cardiac rhythm. However, this is an "off label" use of the AED. In addition, the decision to use disposable electrodes for this purpose should be weighed carefully as these electrodes may be needed in the case of a true cardiac arrest. (See "Automated external defibrillators".)

A few airlines carry more sophisticated monitoring devices capable of transmitting medical data from the aircraft to ground-based support physicians. Such devices usually include an electronic sphygmomanometer, pulse oximeter, digital thermometer, capnometer, glucometer, and 12-lead electrocardiogram. The ability to obtain ECGs makes the management of chest pain consistent with other pre-hospital environments.

Treatment options include oxygen, aspirin, nitrates, atropine, and epinephrine. Enhanced EMKs may include morphine and furosemide. Lidocaine is also available in the EMK, although it is no longer considered a first-line drug for preventing acute ventricular arrhythmias or treating refractory VF or pulseless VT. Although some have advocated lowering the plane's altitude in order to increase cabin oxygen pressure and improve oxygenation during cardiac emergencies [17,29], this is usually not possible as it increases fuel consumption and therefore the ability of the flight to reach its original destination. In addition, for patients not already hypoxic, additional oxygen may not be of benefit [57].

Cardiac arrest — Inflight sudden cardiac arrest (SCA) is particularly challenging. In contrast to cases of SCA that occur in airports, where ventricular fibrillation is the presenting arrhythmia for the majority of cases (87 percent in one small sample [58]), approximately 25 percent of inflight cases present with a shockable arrhythmia [59]. The most likely explanation is slower recognition because the passenger's collapse is unwitnessed during flight (occurs while the passenger is seated or in the lavatory), delaying recognition and intervention.

The best approach to managing a SCA inflight is to follow the protocols of basic life support (BLS). Most aircraft lack the equipment, medications, and medical support to provide complete advanced life support, although such measures should be performed as indicated when possible. Immediate defibrillation as indicated and excellent chest compressions with minimal interruption should take precedence in the large majority of cases involving adult victims. An AED is available on most international carriers and on all domestic and international flights for United States-based airlines. (See "Adult basic life support (BLS) for health care providers" and

"Advanced cardiac life support (ACLS) in adults" and "Pediatric basic life support (BLS) for health care providers" and "Pediatric advanced life support (PALS)".)

In cases where no shock is advised or where the patient is refractory to attempts at defibrillation, it is reasonable to consider early parenteral epinephrine [60-62]. Placing an intravenous (IV) catheter may be difficult inflight, and should not disrupt the performance of chest compressions. Intubation equipment is generally not available, and establishing a secure airway during flight can be difficult.

If return of spontaneous circulation is achieved, the AED should be kept attached and turned on to minimize delays in delivering subsequent shocks as needed. In one case, a passenger survived to hospital discharge after receiving more than 20 shocks [63].

While there are no universally accepted guidelines about when to stop CPR for an inflight cardiac arrest, the IATA Medical Advisory Group has developed guidelines recommending that if there is no sign of recovery 30 minutes after the last attempt at defibrillation (if indicated), despite excellent CPR, the victim may be presumed dead and the airline's protocol for this scenario should be followed [64,65]. The decision whether to continue performing CPR during landing should account for the potential harm to rescuers who remain unstrapped during the landing.

Neurologic events — Neurologic complaints, including syncope, seizure, and dizziness, comprise from 15 to 45 percent of inflight events. In most studies, neurologic complaints are the second most common cause for diversion accounting for between 15 and 35 percent [1,5,7,13,18,55,56]. The time constraints for treatment with thrombolysis following stroke may be one important reason for such diversions.

Assessment of the patient with common neurologic complaints is discussed separately. (See "Approach to the adult patient with syncope in the emergency department" and "Syncope in adults: Clinical manifestations and initial diagnostic evaluation" and "Evaluation and management of the first seizure in adults" and "Convulsive status epilepticus in adults: Management" and "Approach to the patient with dizziness".)

Management of common neurologic conditions is discussed separately. (See "Convulsive status epilepticus in adults: Management".)

In the case of syncope, the clinician must first consider serious causes, such as a cardiac arrhythmia or ischemia, and cerebrovascular disease. (See "Advanced cardiac life support (ACLS) in adults" and "Initial evaluation and management of suspected acute coronary syndrome (myocardial infarction, unstable angina) in the emergency department" and "Initial assessment and management of acute stroke".)

Syncope is most frequently related to a vasovagal episode, which can be precipitated by a myriad of flight-related factors alone or in combination, including prolonged sitting, anxiety or fear of flying, and alcohol consumption. A careful history and focused physical examination. On occasion, an AED monitor may be useful for determining the patient's cardiac rhythm, particularly if a central pulse cannot be palpated reliably. (See 'Cardiac events' above.)

Treatment is generally supportive: laying the person in the recovery position; providing low-flow oxygen to improve unrecognized hypoxia; providing food and drink to treat hypoglycemia [27]. Normal saline is available in limited amounts to treat suspected hypovolemia.

Specific treatment of an inflight seizure is possible on airlines that equip their EMKs with an injectable benzodiazepine, such as those operating under EASA rules. However, neither benzodiazepines nor any other sedative or antiepileptic is currently required by the FAA [1]. A few United States-based airlines carry diazepam in their EMKs. Medications carried by other passengers, or potentially in the patient's own carry-on luggage, may be used in cases of status epilepticus when alternative treatments are not available. Some travelers may be carrying diazepam or lorazepam, which can be crushed and given as a suppository. A known epileptic passenger having a seizure and recovering uneventfully is generally best handled by providing an additional dose of the medication the passenger currently takes. Dextrose is available to treat a seizure or altered mental status precipitated by hypoglycemia. (See "Convulsive status epilepticus in adults: Classification, clinical features, and diagnosis".)

Status epilepticus is an indication for immediate hospital admission, and therefore typically a reason for medical diversion of the flight. Supportive care, such as keeping the airway open, head and neck protection, and aspiration precautions, should be provided. Oxygen may be provided.

Strokes, while less common, are an important concern. The initial assessment of stroke is reviewed separately. Of note, on rare occasions, the inflight environment has been associated with facial nerve (Bell's) palsy that may be mistaken for stroke [66]. Peripheral seventh nerve palsy, as described in the referenced case study, develops acutely as a consequence of middle ear barotrauma and is accompanied by unilateral ear pain. (See "Initial assessment and management of acute stroke" and "Bell's palsy: Pathogenesis, clinical features, and diagnosis in adults".)

Respiratory events — Respiratory events, mainly asthma and COPD exacerbations, comprise approximately 5 to 15 percent of overall complaints aboard aircraft, and 5 to 15 percent of diversions [1,5,7,17,18,55]. Respiratory disease causes the second greatest number of deaths after cardiac events [13,18]. Possible triggers include hypoxia, dry cabin air, and medicine noncompliance due to the logistics of travel. Available treatments include: oxygen, bronchodilator inhalers from the EMK (or from other passengers), epinephrine, injectable glucocorticoids available in some EMKs, and oral and endotracheal airways with bag mask ventilation devices.

Assessment and management of asthma and COPD exacerbations are reviewed separately. (See "Approach to the adult with dyspnea in the emergency department" and "Acute exacerbations of asthma in adults: Home and office management" and "COPD exacerbations: Management".)

Gastrointestinal events — Abdominal pain, nausea, vomiting and, less often, diarrhea are commonly reported inflight complaints [1,7,16,29,31]. Pain, nausea, and vomiting can sometimes be attributed directly to air travel, with the change in barometric pressure, noise and vibration of the plane, and altered diet. The clinician must always first consider a cardiac or other potentially life-threatening cause. Basic gastrointestinal (GI) complaints can be treated with anti-emetics from the EMK and antacids. An antacid may relieve pain from a GI source, but its effectiveness does not rule out a cardiac cause for epigastric pain [67,68]. Intravenous (IV) fluids can be used in severe cases to treat dehydration complicating repeated vomiting and diarrhea. (See "Evaluation of the adult with nontraumatic abdominal or flank pain in the emergency department" and "Approach to the adult with nausea and vomiting".)

Allergic reactions — Minor allergic reactions are easily treated, but the rare case of anaphylaxis can be more challenging [17]. Anaphylaxis can be treated with IM epinephrine and antihistamines found in the EMK, supplemented with IV fluids as needed. Basic airway equipment is available in the EMK. The affected passenger or other passengers may carry an epinephrine auto-injection device that can be used. (See "Anaphylaxis: Emergency treatment".)

Diabetic hypoglycemia — Hypoglycemic episodes in patients with diabetes can occur during air travel. Hypoglycemia should be suspected in any diabetic passenger presenting with altered mental status. The stress of air travel can easily cause the passenger to miss meals or have difficulty coordinating blood glucose monitoring and medication dosages. Hypoglycemic episodes are often mild and can be treated with a source of sugar, for example a snack or juice [32] or glucose gel preparations carried by some airlines. Severe cases may require treatment with the IV dextrose provided in the EMK. Some airlines carry glucagon kits, which may also be carried by the affected passenger or others on board. (See "Hypoglycemia in adults with diabetes mellitus".)

Head injury and other trauma — Items frequently fall from storage bins during flight, and heavy objects can cause serious injury. Severe turbulence may cause objects or passengers to fall. For head injuries, the physician can apply basic first aid, immobilize the cervical spine when necessary, monitor the patient's mental status, and offer advice on the likelihood of severe injury and the need for diversion [17]. Interventions for other injuries may include controlling bleeding with direct pressure or a make-shift tourniquet, immobilizing fractures with splints, slings, or bandages, and general first aid. Whenever practical, and particularly on longer flights, wounds should be cleaned to lower bacterial counts and help prevent infection, especially if sutures will ultimately be required. (See "Initial management of trauma in adults" and "Acute mild traumatic brain injury (concussion) in adults" and "Skull fractures in adults" and "Initial evaluation and management of facial trauma in adults".)

Behavioral problems — Violent behavior aboard airplanes has been occurring more frequently, and it is increasingly publicized by the press [29,69]. A significant increase in social and emotional stress preceding departure has occurred since the events of September 11th, 2001 [31]. Episodes of "air rage," which are frequently triggered by alcohol or drug use or nicotine withdrawal, involve disruptive and possibly violent behavior toward the cabin crew.

When verbal deescalation techniques fail, a physician may be asked to help sedate a violent or disruptive passenger with parenteral medicines, if available in the EMK [70]. Caution is recommended in such cases, particularly when using any drug that may cause respiratory depression, or when asked to manage passengers who have already been restrained by crewmembers [71]. If a sedative is given or restraints are used, the passenger must be observed closely for the remainder of the flight. Restraints that restrict diaphragmatic excursion or may otherwise inhibit breathing should be avoided. A case of a passenger death after administration of a sedative drug to an agitated passenger in-flight is published in the literature [71].

It is important to bear in mind that agitation may be caused by medical conditions, such as hypoglycemia or hypoxia. Elder passengers may become agitated after taking a benzodiazepine intended to control anxiety associated with flying. (See "Assessment and emergency management of the acutely agitated or violent adult" and "Diagnosis of delirium and confusional states".)

Behavioral changes may be caused by substance abuse or the accidental rupture of drug bags being carried in the GI tract of so-called body packers. (See "General approach to drug poisoning in adults" and "Initial management of the critically ill adult with an unknown overdose" and "Internal concealment of drugs of abuse (body packing)".)

Guidance about using verbal deescalation techniques for agitated patients, and management of violent patients is provided separately. Cases of an unruly or disruptive passenger are primarily a security and safety concern, rather than a medical issue. The safety of the aircraft and all aboard it must take precedence. (See "Assessment and emergency management of the acutely agitated or violent adult".)

Infectious disease — Infectious diseases create difficult challenges for commercial airlines. Care must be provided for symptomatic persons while the risks posed to flight crew and other passengers must be managed. New and reemerging infectious diseases can be spread internationally via air transport. It is not unusual for travelers to try to return to their home country, and to disguise their condition, if an infectious disease is discovered while they are abroad. (See "Evaluation of fever in the returning traveler" and "Skin lesions in the returning traveler" and "Approach to illness associated with travel to Latin America and the Caribbean" and "Diseases potentially acquired by travel to East Africa" and "Approach to illness associated with travel to West Africa" and "Diseases potentially acquired by travel to Central Africa" and "Diseases potentially acquired by travel to Southern Africa" and "Diseases potentially acquired by travel to North Africa" and "Approach to illness associated with travel to East Asia" and "Approach to illness associated with travel to Southeast Asia" and "Approach to illness associated with travel to South Asia".)

During flight, contact with passengers who may pose a risk of transmitting a serious infection should be restricted to the greatest extent possible as soon as the risk is identified. This may involve moving surrounding passengers to other seats and using standard precautions, such as gloves and masks. Commercial airlines carry a Universal Precaution Kit (UPK) that contains the equipment used for basic "universal" precautions, including gowns, goggles, masks, and sanitizers. The captain of the aircraft should always be informed about the presence of a reportable condition as he is required to convey that information to the receiving country. (See "Infection prevention: Precautions for preventing transmission of infection".)

According to the International Civil Aviation Organization (ICAO), a passenger is more likely to have a communicable disease when they have a fever (temperature 38°C/100°F or greater) associated with one or more of the following signs or symptoms [72]:

- Obvious ill appearance
- Persistent cough
- Impaired breathing
- Persistent diarrhea or vomiting
- Skin rash
- Bruising or bleeding without recent injury

- Confusion of recent onset

The United States Centers for Disease Control and Prevention (CDC) provides specific guidelines for reportable situations. Other countries have similar approaches. The captain of the aircraft should always be informed about the presence of a reportable condition. The recommendations can be summarized as follows:

- Fever reported to have lasted more than 48 hours

  or

- Fever of any duration AND one or more of the following clinical findings:
  - Skin rash
  - Swollen glands
  - Jaundice
  - Persistent cough
  - Persistent vomiting
  - Difficulty breathing
  - Headache with stiff neck
  - Decreased consciousness
  - Unexplained bleeding
  - Persistent diarrhea

These criteria are defined in greater detail at the CDC website.

LIABILITY AND LEGAL PROTECTION FOR GOOD SAMARITANS

Fear of liability has been cited as a reason preventing trained medical personnel traveling as passengers from assisting during medical emergencies [29,73]. The exact impact of this fear is unclear. Fifty-two resident and attending physicians in New York City were asked specifically if they would volunteer on an airplane if help were requested by the crew. Not one physician surveyed admitted they would refuse to render care, nor did any cite fear of legal liability as a deterrent [73]. Furthermore, a 2002 review of air medical emergencies states that no litigation has been brought against a physician providing aid during an inflight emergency [29]. Nevertheless, there are rare instances when litigation was brought against a physician acting as a good samaritan when assisting a passenger with a medical problem inflight [74]. Knowledge of Good Samaritan legislation can reassure the physician volunteer and ultimately help in the rare instances when it happens.

United States Law — United States law does not obligate a physician to render assistance [29,48,75]. It is, however, widely considered an ethical duty to provide help when possible. The Aviation Medical Assistance Act of 1998 applies when a medical professional volunteers to provide care during a medical emergency. 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) [29,75,76]

The term ''medically qualified individual'' includes any health care practitioner who is "licensed, certified, or otherwise qualified to provide medical care in a State, including a physician, nurse practitioner, physician assistant, nurse, paramedic, and emergency medical technician" [77].

Non-monetary recognition for such assistance, including mile credits, seat upgrades, or other gifts, if accepted, should be understood as a token of gratitude from the airline for the inconvenience caused to the medical volunteer. It should **not** be seen as compensation for services rendered.

International law — Determining which country's laws apply on international flights can be a challenge. The laws of the country from which the aircraft departed, toward which it is traveling, or in which its airline is based may all apply. British and Canadian laws are similar to those of the United States discussed above. A major difference is found in countries that regulate air travel under civil law (eg, France and Germany, among many countries in the European Union). They impose an obligation on physicians to render aid; if aid is not provided, the physician can be punished by a fine or imprisonment [75,78].

Legal guidance — Recommendations for avoiding legal complications include the following:

- 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 [29,75].
- 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.

SOCIETY GUIDELINE LINKS

Links to society and government-sponsored guidelines from selected countries and regions around the world are provided separately. (See "Society guideline links: Management of inflight medical events".)

SUMMARY AND RECOMMENDATIONS

- **Epidemiology** – The number of inflight medical emergencies and non-emergency events is increasing in proportion with the general increase in air travel worldwide, although the precise incidence is unknown. Cardiac, neurologic, and respiratory complaints comprise the more serious emergencies, as defined by aircraft diversion or use of ground-based medical support (GBMS) assistance. Of these, cardiac emergencies are most common. Most medical events during flight are not emergencies. (See 'Epidemiology' above.)
- **Cabin reduced oxygen** – The aircraft cabin is pressurized typically to the equivalent of 4000 to 8000 feet (1400 to 2500 m) above sea level. In individuals with cardiopulmonary disease, the ability to compensate for this relatively hypoxic environment may be insufficient. For them, a relatively small drop in oxygen saturation may occur on the steep part of the oxyhemoglobin dissociation curve, severely compromising their

cardiopulmonary reserves, and precipitating a medical emergency such as cardiac ischemia. (See 'Reduced oxygen' above.)

- **Cabin reduced air pressure** – Diminished cabin air pressure during flight can lead to the expansion of gas volume up to 30 percent compared with sea level. A medical emergency can ensue if the expanding gas is constrained within a confined space such as the pleural cavity (pneumothorax), the middle ear (tympanic membrane rupture), or another body cavity after surgery. Gas expansion can also create problems with inflated medical devices, such as tracheostomy cuffs, gastric feeding tubes, bladder catheters, and insulin pumps. (See 'Reduced ambient pressure and potential complications' above.)

- **Other cabin factors** – The low humidity of cabin air can exacerbate pulmonary problems such as asthma and may predispose some passengers to dehydration. Turbulence can cause head trauma and other injuries. (See 'Air quality' above and 'General environmental factors' above.)

- **Airline medical protocols** – Each airline has its own medical emergency protocol. Under all circumstances, the captain remains the ultimate decision maker for any commercial aircraft. (See 'Airline protocols for managing medical emergencies' above.)

- **Resources on board an aircraft** – Major commercial aircraft carry three types of kits: a First Aid Kit (FAK), a Universal Precaution Kit (UPK), and the Emergency Medical Kit (EMK). The EMK contains specified equipment (eg, sphygmomanometer, stethoscope) and medications (eg, aspirin, nitrates, epinephrine, bronchodilators, dextrose) (table 2). Most international airlines carry automated external defibrillators (AED), and oxygen is available. GBMS from physicians with expertise in managing inflight medical emergencies is readily available on most flights. The sick passenger or other passengers aboard may have useful medications and medical equipment, although medications from the EMK are preferred. (See 'Resources on board an aircraft' above.)

- **Common inflight medical emergencies and complaints** – The most common serious inflight medical emergencies that lead to diversions result from cardiac, neurologic, and pulmonary disease (see 'Common inflight medical emergencies and complaints' above):

  - **Cardiac events** – Cardiac complaints comprise about 20 percent of inflight medical emergencies, and in most studies are the most common cause of aircraft diversion and passenger death. Chest pain and angina are most common. Aspirin, nitrates, and oxygen are available for treatment. In addition to defibrillation, AEDs can be used to assess a patient's cardiac rhythm. (See 'Cardiac events' above.)

- **Neurologic events** – Syncope, seizure, and dizziness are the most common neurologic emergencies. Treatment options are limited, and care is generally supportive. Intravenous (IV) normal saline and dextrose are available. Some airlines include an injectable benzodiazepine in their EMK. (See 'Neurologic events' above.)

- **Respiratory events** – Asthma and COPD exacerbations comprise about 5 to 15 percent of diversions and represent the second greatest number of deaths. Available treatments include: oxygen, bronchodilators either in the EMK or from other passengers, epinephrine, injectable glucocorticoids in some EMKs, and oral and endotracheal airways with bag mask ventilation devices. (See 'Respiratory events' above.)

- **Gastrointestinal events** – Abdominal pain and nausea are common aboard aircraft, but they are rarely medical emergencies. Other emergencies, such as allergic and hypoglycemic reactions can occur. Basic equipment and medications are available for management. (See 'Gastrointestinal events' above.)

- **Trauma and behavioral problems** – Minor trauma and behavioral problems occurs with some frequency aboard commercial air flights. Management options include applying basic first aid, immobilizing the cervical spine when necessary, controlling bleeding with direct pressure or a makeshift tourniquet, and immobilizing fractures with splints, slings, or bandages. When verbal de-escalation techniques fail, a physician may be asked to help sedate a violent or disruptive passenger with parenteral medicines, if available in the EMK, but a medical condition such as hypoglycemia or hypoxia must be ruled out first. (See 'Head injury and other trauma' above and 'Behavioral problems' above.)

- **Mitigating spread of infectious disease** – During flight, contact with passengers who may pose a risk of transmitting a serious infection should be restricted to the greatest extent possible as soon as the risk is identified. Passengers with fever (temperature 38°C/100°F or greater) associated with other concerning clinical findings represent reportable cases in most countries. (See 'Infectious disease' above.)

- **Liability and legal protection** – Clinicians who come to the assistance of passengers aboard aircraft are protected from liability in the United States, Canada, and Great Britain by Good Samaritan legislation. According to the laws of France, Germany, and other European nations, physicians are obligated to provide aid when it is requested by the crew. Guidelines to help avoid legal pitfalls are included above. (See 'Liability and legal protection for Good Samaritans' above.)

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Topic 185 Version 29.0

GRAPHICS

Hypobaric conditions at increasing altitude

Altitude, ft	Barometric pressure, mmHg	Atmospheric PO_2, mmHg	Tracheal PO_2, mmHg	Gas density*	Gas volume¶
0 (sea level)	760	159	149	1	1
2000	707	148	138	-	-
4000	656	137	128	0.9	1.1
5000	632	132	122	0.8	1.2
8000	564	118	108	-	1.4
10,000	523	109	100	0.7	1.5
15,000	428	89	80	0.6	1.9
30,000	226	47	38	0.3	4
40,000	141	29	20	0.2	7.6

Fall in ambient pressure and PO_2 at increasing altitude during air travel in commercial airliners. Pressurization of the cabin limits the reduction in cabin pressure, thereby limiting the reduction in inspired PO_2.

* Ratio of density at altitude to density at sea level.

¶ Ratio of volume occupied by a fixed amount of gas at altitude to the volume occupied at sea level.

Adapted from Gong H. Advising pulmonary patients about commercial air travel. J Respir Dis 1990; 11:484.

Graphic 77616 Version 5.0

Emergency medical kit for commercial airlines

Medications	Equipment
▪ Epinephrine 1 mg/mL for IM injection – for allergic emergencies ▪ Epinephrine 1 mg/10 mL for IV/IO/ET use – for cardiac arrest ▪ Antihistamine* ▪ Dextrose 50% 50 mL (or equivalent) ▪ Nitroglycerin tablets or spray ▪ Major analgesic, injectable or oral ▪ Sedative anticonvulsant* ▪ Antipsychotic (eg, haloperidol) ▪ Antiemetic, injectable or oral dissolvable (eg, ondansetron) ▪ Bronchial dilator inhaler with spacer ▪ Atropine* ▪ Adrenocortical steroid, injectable or oral absorption equivalent* ▪ Diuretic* ▪ Sodium chloride 0.9% (1000 mL recommended) ▪ Acetylsalicylic acid for oral use ▪ Oral beta blocker ▪ List of medications – generic name, plus trade name if indicated on the item	▪ Stethoscope ▪ Sphygmomanometer (electronic preferred) ▪ Airways, oropharyngeal (appropriate range of sizes) ▪ Syringes (appropriate range of sizes) ▪ Needles (appropriate range of sizes) ▪ IV catheters (appropriate range of sizes) ▪ Antiseptic wipes ▪ Gloves (disposable) ▪ Sharps disposal box ▪ Urinary catheter with sterile lubricating gel ▪ System for delivering intravenous fluid ▪ Venous tourniquet ▪ Sponge gauze ▪ Tape adhesive ▪ Surgical mask ▪ Flashlight and batteries (operator may decide to have one per aircraft in an easily accessible location) ▪ Thermometer (non-mercury) ▪ Emergency tracheal catheter (or large gauge intravenous cannula) ▪ Umbilical cord clamp ▪ Bag-valve mask ▪ List of equipment ▪ Basic and Advanced Life Support cards

- Some kits may include: epinephrine auto-injector, glucagon, naloxone, ondansetron (oral), and/or injectable diazepam.
- When available, auto-injectors can be used by the cabin crew of some airlines under order from a ground medical advisor if there are no health professionals on board.
- Alternative methods of administration (eg, nasal spray, sub-lingual spray, oral-dissolving tablet) may replace injections in order to facilitate treatment by a volunteer, including personnel who are not trained to use this method (eg, cabin crew), under direction from a ground medical advisor or based upon a standing order from the airline.
- Ampules of epinephrine 1 mg/mL were previously labeled as 1:1000, and ampules of epinephrine 1 mg/10 mL were previously labeled as 1:10000, but to help prevent medication errors, ratio expressions were removed from epinephrine labels in the United States in 2016.

IV: intravenous; IM: intramuscular; IO: intraosseous; ET: endotracheal.

* Injectable.

Graphic 53375 Version 11.0

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