

In-Flight Medical Emergencies

A Review

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IMPORTANCE In-flight medical emergencies (IMEs) are common and occur in a complex environment with limited medical resources. Health care personnel are often asked to assist affected passengers and the flight team, and many have limited experience in this environment.

OBSERVATIONS In-flight medical emergencies are estimated to occur in approximately 1 per 604 flights, or 24 to 130 IMEs per 1 million passengers. These events happen in a unique environment, with airplane cabin pressurization equivalent to an altitude of 5000 to 8000 ft during flight, exposing patients to a low partial pressure of oxygen and low humidity. Minimum requirements for emergency medical kit equipment in the United States include an automated external defibrillator; equipment to obtain a basic assessment, hemorrhage control, and initiation of an intravenous line; and medications to treat basic conditions. Other countries have different minimum medical kit standards, and individual airlines have expanded the contents of their medical kit. The most common IMEs involve syncope or near-syncope (32.7%) and gastrointestinal (14.8%), respiratory (10.1%), and cardiovascular (7.0%) symptoms. Diversion of the aircraft from landing at the scheduled destination to a different airport because of a medical emergency occurs in an estimated 4.4% (95% CI, 4.3%-4.6%) of IMEs. Protections for medical volunteers who respond to IMEs in the United States include a Good Samaritan provision of the Aviation Medical Assistance Act and components of the Montreal Convention, although the duty to respond and legal protections vary across countries. Medical volunteers should identify their background and skills, perform an assessment, and report findings to ground-based medical support personnel through the flight crew. Ground-based recommendations ultimately guide interventions on board.

CONCLUSIONS AND RELEVANCE In-flight medical emergencies most commonly involve near-syncope and gastrointestinal, respiratory, and cardiovascular symptoms. Health care professionals can assist during these emergencies as part of a collaborative team involving the flight crew and ground-based physicians.

JAMA. 2018;320(24):2580-2590. doi:10.1001/jama.2018.19842

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Section Editors: Edward Livingston, MD, Deputy Editor, and Mary McGrae McDermott, MD, Senior Editor.

In-flight medical emergencies (IMEs) are unique events for which traveling physicians, nurses, and other health care professionals may render medical assistance. Cruising at 35 000 ft with limited medical equipment, often hours away from the closest medical facility, creates an unfamiliar care challenge for many health care professionals. This clinical review focuses on IME data and offers guidance to assist medical professionals who may encounter these events using both literature and the authors' insights providing airline care guidance for IMEs.

air passenger, air travel, aircraft, airline, aviation, commercial air, flight, and fitness to fly (n = 14 842). Scanning the titles to identify appropriateness and searching bibliographies yielded the final list of relevant articles (n = 765). Each article was assessed for completeness of data reporting and importance to management and prevention of IMEs. Based on this assessment, a total of 317 articles were included in the review. Frequency data were extracted and means and 95% confidence intervals were calculated when appropriate.

Methods

A literature search was conducted in MEDLINE using PubMed for English-only articles published between January 1, 1990, and June 2, 2018, using the terms *air emergency, air emergencies,*

Observations

Epidemiology

The estimated prevalence of IMEs is 1 in 604 flights based on a review of 11 920 requested ground consultations from 5 large

domestic and international airlines from 2008 to 2010.¹ This is likely an underrepresentation of all IMEs because many minor incidents do not result in consultations. Other IME frequency estimates from individual airlines with data from 2009 to 2013 ranged from 24 to 130 IMEs per 1 million passengers.^{2,3} Given that 4 billion commercial airline passengers travel worldwide annually,⁴ it is possible that 260 to 1420 IMEs occur daily worldwide.

A total of 14 articles described the relative frequency of medical conditions comprising IMEs aboard commercial aircraft (Table 1).^{1,3,5-15} The aggregate frequency of medical conditions among 49 100 IMEs showed that syncope or near-syncope was the most common IME (32.7%); other common condition categories included those with gastrointestinal (14.8%), respiratory (10.1%), and cardiovascular (7.0%) symptoms. In-flight cardiac arrest was rare (0.2% of IMEs).

Diversion refers to altering a flight destination for a medical emergency; based on 14 publications reporting 56 599 IMEs (Table 2), diversion occurred in 2515 flights with IMEs (4.4%; 95% CI, 4.3%-4.6%).^{1-3,5-10,13-17}

Pathophysiology

Commercial aircraft fly at a cruising altitude (during level flight) of 30 000 to 40 000 ft, and passenger cabins are pressurized to 12 psi to 11 psi, which is equivalent to being at an altitude of 5000 to 8000 ft.¹⁸⁻²² This pressurization leads to expansion of closed gas-containing spaces in the body (eg, sinuses and middle ear) and nonphysiological gas collections (eg, pneumothorax or following gastrointestinal, ocular, or intracranial surgery).²³ At 8000 ft of altitude or equivalent, the volume of gas in an enclosed space increases by approximately 30%²⁴; altitude changes commonly trigger discomfort in patients, especially those with existing upper respiratory tract inflammation or infection, including sinusitis or otitis media.

The aircraft cabin has a lower partial pressure of oxygen at altitude, with resultant mild hypoxia in healthy passengers (decreasing mean arterial oxygen saturation from 97% to 93%). This effect can be more pronounced or symptomatic in passengers with existing pulmonary conditions.²³⁻²⁶ Passengers with hypoxia or respiratory insufficiency at baseline may benefit from supplemental oxygen at cruising altitude²⁷⁻²⁹; alternatively, the baseline flow of oxygen may need to be increased for the duration of a flight. Use of a portable oxygen concentrator during flight needs approval by the airline, a physician's certification of need, and sufficient battery life, all typically coordinated at least 48 hours prior to the flight.³⁰⁻³²

Prolonged sitting and hypoxia may trigger decreased venous flow, systemic inflammation, and platelet activation, which explains the association between air travel and venous thromboembolism,^{33,34} although controversy exists regarding the risk compared with the general population.³⁴⁻³⁸ Symptoms of deep venous thrombosis or pulmonary embolism most commonly present hours to days after completing air travel³⁹ but can occur on flights of long duration or during multiple flights in succession.^{40,41} The risk of lower limb venous thrombosis in high-risk passengers may be up to 5% per flight,⁴¹ and symptomless venous thromboembolism may occur in up to 10% of passengers on flights of long duration (ie, >4 hours).⁴²

Cabin air, drawn from an outside dry environment at altitude and pressurized and dehumidified by cycling through the engine compartment, may contribute to dehydration among passengers.^{21,24,43}

Recycling of air may also expose passengers to potential allergens, even when the source of allergens is several rows away from a passenger. Although the enclosed and limited-space environment of aircraft raises concern for transmission of communicable diseases,^{44,45} preexisting exposure is a more common infectious source.

Emergency Medical Equipment

The Federal Aviation Administration (FAA) has minimum requirements for contents of an emergency medical kit aboard US airlines (Table 3).⁴⁶ Non-US airlines have different minimum requirements,^{6,47} and individual airlines vary widely in the contents of their emergency medical kits.²³ The FAA requires automated external defibrillators on all airplanes with "a maximum payload capacity of more than 7,500 pounds and with at least one flight attendant,"⁴⁶ but automated external defibrillators are not currently mandated for European airlines.^{48,49} The FAA-mandated medical kit contains protective gloves and equipment for a basic medical assessment, hemorrhage control, and initiation of an intravenous line (Table 3). The FAA-mandated medical kit contents also include medications to treat mild pain, allergic reactions, bronchoconstriction, hypoglycemia, dehydration, and some cardiac conditions. Common enhancements to the medical kit include a glucometer, urinary catheter, and medications for nausea, moderate to severe pain, seizures, and additional cardiac indications. Controlled substances are not commonly available in medical kits on US airlines but may be available in kits on some non-US airlines.

Commercial aircraft carry oxygen bottles intended for short-term use by flight crew during sudden depressurization. Airline oxygen bottles deliver oxygen to passengers at low (2 L/min) or high (4 L/min) settings, which may be sufficient to address the need for oxygen at cruising altitudes.^{27,50} These oxygen stores generally do not fully meet the needs of persons with respiratory failure. The number of oxygen bottles on an individual aircraft varies, and there is no requirement to carry enough portable oxygen to administer to a passenger for the duration of a flight.

Several organizations recommend contents for an optimal medical kit.⁵¹⁻⁵⁸ Some have suggested that common emergency medical kits lack adequate equipment for pediatric emergencies.^{59,60} Recommended improvements include standardization of content and location of equipment,⁶¹ availability of pulse oximetry,⁶⁰ and additional medications, including a "major analgesic,"⁵⁶ naloxone,⁶⁰ and antibiotics.⁶² Despite these suggestions, current basic emergency medical kits contain sufficient equipment to handle most IMEs; only a minority of cases require a medication or performance of advanced procedures.¹

Ground-Based Medical Support

Ground-based medical support comes from trained medical personnel who provide recommendations for IMEs and preflight screenings.⁶³ Most airlines contract with third-party entities to provide this service.^{1,13,15,64,65} When an IME occurs on an aircraft, a flight attendant notifies the pilot in command; next, that pilot establishes radio or satellite telephone communications with the ground-based medical support center and the airline operations center. The flight attendant relays information to and from ground-based support via the pilot or through headsets in the cabin. Communication clarity is often a challenge, including

Table 1. Frequency of In-Flight Medical Emergencies by Medical Condition

Source	Study Details	Total IMEs, No.	Frequency of IMEs by Condition, No. (%)											Other/Unknown
			Syncope/ Near-Syncope	Gastrointestinal	Respiratory	Cardiovascular ^a	Neurological	Trauma	Psychiatric/ Intoxication	Allergic	Obstetric/ Gynecologic	Cardiac Arrest		
Peterson et al, ¹ 2013	5 Airlines, 34 mo	11 920	4463 (37.4)	1625 (13.6)	1447 (12.1)	920 (7.7)	1050 (8.8)	363 (3.0)	287 (2.4)	265 (2.2)	61 (0.5)	38 (0.3)	1401 (11.8)	
Mahony et al, ⁵ 2011	1 Airline, 108 mo	11 326	4648 (41.1)	2214 (19.5)	1805 (15.9)	258 (2.3)	450 (4.0)	354 (3.1)	367 (3.2)	257 (2.3)	4 (<0.1)		969 (8.6)	
Sand et al, ⁶ 2009	2 Airlines, 60 mo	10 189	5307 (52.1)	1286 (12.6)	231 (2.3)	675 (6.6)	250 (2.5)	359 (6.0)	616 (6.0)	222 (2.2)	62 (0.6)	52 (0.5)	1129 (11.1)	
Hung et al, ⁷ 2013	1 Airline, 60 mo	4068	1310 (32.2)		359 (8.8)	248 (6.1)	727 (17.9)	113 (2.8)	92 (2.3)		56 (1.4)	30 (0.7) ^b	1163 (28.6)	
Delaune et al, ⁸ 2003	1 Airline, 12 mo	2279	348 (15.3)	271 (11.9)	251 (11.0)	285 (12.5)	312 (13.7)	279 (12.2)	84 (3.7)	63 (2.8)	31 (1.4)	7 (0.3) ^b	355 (15.6)	
Kim et al, ² 2017	1 Airline, 48 mo	2818	510 (18.1)	554 (19.7)	279 (9.9)	215 (7.6)	120 (4.3)	398 (14.1)	111 (3.9)	132 (4.7)	30 (1.1)	15 (0.5) ^b	469 (16.6)	
Sirven et al, ⁹ 2002	1 Airline, 72 mo	2042	34 (1.7)	201 (9.8)	173 (8.5)	274 (13.4)	592 (29.0)		46 (2.3)	71 (3.5)	46 (2.3)	8 (0.4)	597 (29.2)	
Kesapli et al, ³ 2015	1 Airline, 36 mo	1312	62 (4.7)	140 (10.7)	145 (11.1)	60 (4.6)	60 (4.6)	266 (20.1)	41 (3.1)	10 (0.8)		9 (0.7)	519 (39.6)	
DeJohn et al, ¹⁰ 2000	5 Airlines, 12 mo	1132	254 (22.4)	90 (8.0)	92 (8.1)	253 (22.3)	134 (11.8)	60 (5.3)	38 (3.4)	27 (2.4)	33 (2.9)	3 (0.3)	148 (13.1)	
Chan et al, ¹¹ 2002	1 Airport, 12 mo	744	208 (28.0)	173 (23.3)	60 (8.1)	80 (10.8)	32 (4.3)	73 (9.8)				5 (0.7)	113 (15.2)	
Qureshi and Porter, ¹² 2005	1 Airline, 6 mo	507	128 (25.2)	4 (7.8)	69 (13.6)	46 (9.1)	1 (0.2)	37 (7.3)	3 (0.6)		1 (0.2)		182 (35.6)	
Szmajler et al, ¹³ 2001	1 Airline, 120 mo	380	62 (16.3)	59 (15.5)	14 (3.7)	45 (11.8)	35 (9.2)	11 (2.9)	35 (9.2)	9 (2.4)	15 (3.9)	3 (0.8)	92 (24.2)	
Cummins and Schubach, ¹⁴ 1989	1 Airport, 12 mo	192	7 (3.6)	28 (14.6)	15 (7.8)	37 (19.3)	16 (8.3)	26 (13.5)	2 (1.0)		4 (2.1)	1 (0.5)	56 (29.2)	
Baltsezak, ¹⁵ 2008	1 Airline, 12 mo	191	28 (14.7)	68 (35.6)	13 (6.8)	18 (9.4)	9 (4.7)	6 (3.1)	6 (3.1)	7 (3.7)	3 (1.6)	1 (0.5)	32 (16.8)	
Total		49 100	16 059 (32.7)	7268 (14.8)	4953 (10.1)	3414 (7.0)	2722 (5.5)	2345 (4.8)	1728 (3.5)	798 (1.6)	346 (0.7)	120 (0.2)	6062 (12.3)	

Abbreviation: IME, in-flight medical emergency.

^a Cardiovascular cases do not include cases of reported in-flight cardiac arrest.

^b Cardiac arrest cases are reported independent of other medical categories within the total.

Table 2. Frequency of Aircraft Diversions for In-Flight Medical Emergencies

Source	Study Details	Total No. of In-Flight Medical Emergencies	No. (%) [95% CI] With Diversions
Peterson et al, ¹ 2013	5 Airlines, 34 mo	11 920	875 (7.3) [6.9-7.8]
Mahony et al, ⁵ 2011	1 Airline, 108 mo	11 326	276 (2.4) [2.2-2.7]
Sand et al, ⁶ 2009	2 Airlines, 60 mo	10 189	279 (2.7) [2.4-3.1]
Valani et al, ¹⁶ 2010	1 Airline, 60 mo	5386	220 (4.1) [3.6-4.6]
Hung et al, ⁷ 2013	1 Airline, 60 mo	4068	46 (1.1) [0.8-1.5]
Weinlich et al, ¹⁷ 2009	1 Airline, 36 mo	3364	94 (2.8) [2.3-3.4]
Kim et al, ² 2017	1 Airline, 48 mo	2818	15 (0.5) [0.3-0.9]
Delaune et al, ⁸ 2003	1 Airline, 12 mo	2279	181 (7.9) [6.9-9.1]
Sirven et al, ⁹ 2002	1 Airline, 72 mo	2042	312 (15.3) [13.7-16.9]
Kesapli et al, ³ 2015	1 Airline, 36 mo	1312	22 (1.7) [1.1-2.5]
DeJohn et al, ¹⁰ 2000	5 Airlines, 12 mo	1132	145 (12.8) [10.9-14.9]
Szmajer et al, ¹³ 2001	1 Airline, 120 mo	380	37 (9.7) [6.9-13.2]
Cummins and Schubach, ¹⁴ 1989	1 Airport, 12 mo	192	7 (3.6) [1.5-7.4]
Baltsezak, ¹⁵ 2008	1 Airline, 12 mo	191	6 (3.1) [1.2-6.7]
Total		56 599	2515 (4.4) [4.3-4.6]

device issues and relaying of information, making well-articulated exchanges essential. The effect of ground-based medical support on patient outcomes following an IME has not been studied.

The Medical Volunteer Role

Guided by individual airline policies, airline personnel often seek aid from trained medical professionals, augmenting existing capabilities. Medical volunteers are not generally required to carry proof of their medical license, although this varies by individual airline policy. Volunteers who have a business card or licensure documents ready to share may allay concerns by flight teams about ability to aid. More importantly, medical volunteers must honestly consider their own capability of providing medical care, and if they choose to do so, they should not be under the influence of alcohol or other drugs.⁶⁶ In one study, approximately half of IME aid was by a physician, 25% by a nurse or other emergency personnel, and 25% by flight crew alone.¹ If multiple potential volunteers exist, a collegial conversation about capabilities is optimal; for instance, a specialist physician may be less capable to assess and manage a patient with an IME than another medical volunteer with training and experience more directly linked to the symptoms or condition.

In most cases, the primary role of a medical volunteer is to gather information, assess an ill or injured passenger, aid with communications with any ground-based support, and potentially administer medications or perform procedures. Flight crew particularly seek the recommendations of ground-based medical experts before use of medications or equipment from the emergency medical kit, considering the variability in training and experience of onboard volunteers.⁶⁷ Medical volunteers may be asked to provide a recommendation, but a consulting ground-based physician usually makes a final recommendation about care. The key to success is for everyone involved to contribute their expertise as part of a collaborative team, with the sole goal of ensuring the best interest of the patient with the IME in consideration of all passengers on board.

Legal and Ethical Considerations for Medical Volunteers

In the United States, the Aviation Medical Assistance Act (also referred to as a "Good Samaritan" shield) protects passengers who pro-

vide medical assistance from liability except in cases of gross negligence or willful misconduct.⁶⁸ Medical volunteers who seek compensation in return for providing aid (such as money, seat upgrades, mileage points, or other items of value) may jeopardize their standing under existing immunity laws, although no case law related to this exists.⁶⁹

Flights outside of the United States are governed by a complex combination of public and private international laws, including the Warsaw Convention, Montreal Convention, and Tokyo Convention.⁶⁹ In addition to differences in "Good Samaritan" volunteer protections, which are not present in many other countries, the duty to respond also varies by country. For example, in the United States, Canada, England, and Singapore, there is no legal duty for an off-duty medical professional to assist during an IME.⁶⁹⁻⁷¹ Conversely, Australia and many European countries require physicians to render assistance during IMEs as defined by case law and civil law codes.^{69,72,73} Regardless of applicable laws, physicians often feel an ethical duty to act.⁷⁴ According to one study, only 1 case has occurred in the United States involving a physician being sued for assisting in an IME, and that case was dismissed without hearing.⁶⁹ Considering existing legal protections and international requirements, medical assistance rendered by a capable physician is of little personal legal risk and is supported by experts in aviation medicine.^{1,56,63,66}

Aircraft Diversion

Diversion, which involves changing a landing destination because of an IME, is appropriate for several types of medical emergency. A commercial aircraft is not a medical facility, has limited onboard medical equipment, and has no dedicated medical personnel on board who can adequately address all events. However, the decision to divert involves consideration of multiple factors, many unknown to an onboard medical volunteer. Aircraft commonly take off with more fuel than is safe for landing; immediate diversion soon after departure may require dumping a large amount of fuel into the atmosphere (a feature not available in many newer aircraft). The closest possible diversion airport may not have appropriate medical capabilities to manage a patient, negating a

Table 3. Contents of Emergency Medical Kits

	FAA-Mandated Emergency Medical Kit ^a	Additional Contents ^b
Equipment	Airways, oropharyngeal Adhesive tape, 1-in Alcohol sponges Cardiopulmonary resuscitation mask Intravenous administration set Needles Protective gloves Sphygmomanometer Stethoscope Syringes Tape scissors Tourniquet (for intravenous catheter placement) Manual resuscitation device, 3 masks Instructions on kit use	Burn dressings Cord clamps Disposable scalpel Endotracheal tubes Emergency tracheal catheter Glucometer Insulin syringe Laryngoscope blade Pulse oximeter Skin closure strips Thermometer Tourniquet (for hemorrhage control) Umbilical cord clamp Urinary catheter
Medications	Analgesic, nonnarcotic Antihistamine, 50 mg, injectable Antihistamine tablets, 25 mg Aspirin tablets, 325 mg Atropine, 0.5 mg, 5 mL Bronchodilator, inhaled Dextrose, 50%/50 mL, injectable Epinephrine, 1:1000, 1 mL, injectable Epinephrine, 1:10 000, 2 mL, injectable Lidocaine, 5 mL, 20 mg/mL, injectable Nitroglycerin tablets Saline solution, 500 mL	Antacid tablets (eg, calcium carbonate) Calcium chloride Chlorphenamine Cinnarizine Decongestant spray Dexamethasone Diazepam Diclofenac sodium, injectable Diclofenac sodium tablets Digoxin Dimenhydrinate Epinephrine autoinjector Fexofenadine Furosemide Glucose gel Glucagon Haloperidol Hydrocortisone Hyoscine Ibuprofen Ketorolac injectable Lorazepam Meclizine Methylprednisolone Metoprolol Morphine Nalbuphine Naloxone Ondansetron Oxytocin Promethazine

^a Contents of kit required by the Federal Aviation Administration (FAA).⁴⁶

^b Additional contents contained in some airlines' emergency medical kits.

time-to-treatment benefit of going to the closest airport. Even if a facility seems nearby, it may take 30 minutes to reach the ground from cruising altitude; flying onward may not result in any meaningful delay in medical treatment. Some patients may not desire to be diverted, especially when they are returning to their home cities, where they can be transported to a familiar health system. Even with a request for emergency medical services to be available at the time of arrival of a patient with an IME, only a third of passengers are transported by emergency medical services to a hospital, and only a third of those transported are admitted to the hospital, either because their condition was not serious or because they ultimately refused care.¹

The pilot in command, in coordination with the flight dispatcher, coordinates all operational decisions for the aircraft and is responsible for decisions about aircraft diversion. Any other persons involved in an IME, including flight staff, volunteers, or ground-

support experts, are offering recommendations rather than making decisions about diversion. To make these decisions, the pilot in command seeks input from involved medical volunteers while relying largely on the opinion of ground-support physicians. Input from their operations center often affects these decisions, which must account for airport capabilities, fuel on board the aircraft, and other variables.

The direct cost of diversion ranges from \$20 000 to \$725 000^{6,60} and varies based on logistical considerations in addition to direct and time costs to reroute other passengers. Although the benefit of diversion is sometimes clear, such as for a passenger who has been resuscitated after cardiac arrest or who has new-onset stroke symptoms, most cases of diversion require balancing multiple factors including the passenger's condition. In one study, the medical conditions that most frequently resulted in diversion included cardiac arrest, obstetric emergencies, cardiac symptoms, and suspected stroke.¹ Despite these symptoms, most patients with an IME are managed with onboard interventions and the situation does not result in diversion, transport to a hospital, or admission. The best decision path for most circumstances is a collaboration among airline personnel, ground-based expert physicians, and any onboard volunteer physicians or other health care professionals. In this manner, it is much like making complex medical decisions in other health care environments with the assistance of a specialty consultant.

Diversion decisions involving a patient in cardiac arrest are complex. If the event occurs at cruising altitude, it can take longer than 30 minutes to land regardless of physical distance to an airport. The pilot and ground-based expert consider these factors and the pilot decides about diversion. Diversion decisions may also depend on operational considerations and the distress of other passengers; in some settings, especially when resuscitation fails, diversion away from the intended destination may not be in the best interest of family members or other passengers.

Clinical Assessment and Management

General Approach to an IME

On request of a flight crew for assistance, medical professionals should identify themselves and report their training and current clinical practice. Next, the assessment should determine the type and duration of symptoms, presence of high-risk symptoms (eg, chest pain, shortness of breath, or focal weakness), vital signs (pulse, blood pressure, and respirations), mental status, and pertinent physical findings. The flight attendant should obtain the emergency medical kit, and oxygen should be administered to the person with the IME if needed. After gathering patient information, the flight attendant should establish contact with any ground-based medical support personnel available and relay this information, including any recommendations for therapeutic interventions or diversion concerns. Any IME triggering a request for a medical volunteer on board is serious enough to warrant contact with ground-based medical personnel; airlines arrange this service for this explicit purpose. Airlines commonly have standardized forms to document care; health care professionals involved in IMEs should request and use these forms. Additional individual recommendations are shown in Figure 1 and Figure 2 (see also the Supplement) along with key diagnoses to consider when assessing passengers with these symptoms (Table 4).

Figure 1. Management of In-Flight Medical Emergencies: Syncope, Gastrointestinal, Respiratory, Cardiovascular, Stroke-like, and Seizure

<p> SYNCOPE / NEAR-SYNCOPE</p> <p>— 30% of all in-flight emergencies —</p> <p>Initial assessment-suspect</p> <ul style="list-style-type: none"> <input type="checkbox"/> Vasovagal: Pale, diaphoretic, improves with simple measures in 15-30 min. <input type="checkbox"/> Cardiac cause (eg, myocardial infarction): Chest pain, dyspnea, arm or jaw pain, persistent bradycardia. <input type="checkbox"/> Pulmonary: Dyspnea, pleuritic chest pain. <input type="checkbox"/> Stroke: Slurred speech, facial droop, or arm weakness. <input type="checkbox"/> Hypoglycemia: Diaphoretic, cool skin; assess with glucometer if available. <p>Management and expected course</p> <ul style="list-style-type: none"> <input type="checkbox"/> If unconscious ▶ Lie flat, elevate legs, apply oxygen. If no pulse or signs of life, follow cardiac arrest card. <input type="checkbox"/> If transient syncope ▶ Supine position, elevate legs. Oral fluids with head raised if nausea absent. If improves in 15-30 min, slowly sit up and return to seat if tolerated. <input type="checkbox"/> If hypoglycemia ▶ Oral glucose or 25 g of dextrose 50% intravenously. <input type="checkbox"/> If other conditions suspected ▶ Refer to relevant card. <input type="checkbox"/> If no improvement or not progressing as expected ▶ Contact ground-based medical support for additional recommendations. 	<p> CARDIOVASCULAR SYMPTOMS</p> <p>— 7% of all in-flight emergencies —</p> <p>Initial assessment</p> <ul style="list-style-type: none"> <input type="checkbox"/> Identify if any prior myocardial infarction or other cardiovascular history. <input type="checkbox"/> In some settings, a 12-lead electrocardiogram may be obtained and transmitted for ground review (and/or volunteer review if qualified to read). <input type="checkbox"/> Suspected acute coronary syndrome: Chest pain, dyspnea, arm or jaw pain. <input type="checkbox"/> Suspected arrhythmia: Persistent bradycardia, tachycardia, or irregular heartbeat. <input type="checkbox"/> Suspected dyspepsia: Isolated epigastric burning with no associated symptoms. This is a consideration of exclusion, supported by history of similar symptoms. <p>Management and expected course</p> <ul style="list-style-type: none"> <input type="checkbox"/> If suspected acute coronary syndrome ▶ Aspirin, 325 mg orally; nitroglycerin, 0.4 mg sublingually every 5-10 min (if systolic blood pressure is ≥ 100 mm Hg). <input type="checkbox"/> If any dyspnea or respiratory distress ▶ Give oxygen, unless saturations are known to be near or at normal levels. <input type="checkbox"/> If dyspepsia suspected ▶ Antacids or other analgesics can be given after appropriate risk stratification. Alternative causes should first be considered. <input type="checkbox"/> If persistent or additional symptoms ▶ Contact ground-based medical support for additional recommendations.
<p> GASTROINTESTINAL ILLNESS</p> <p>— 15% of all in-flight emergencies —</p> <p>Initial assessment</p> <ul style="list-style-type: none"> <input type="checkbox"/> Identify extent and timing of symptoms, including nausea, vomiting, diarrhea, bleeding, and specifics of any abdominal pain (location, quality, and severity). <p>Management and expected course</p> <ul style="list-style-type: none"> <input type="checkbox"/> If nausea/emesis ▶ Use an oral antiemetic if available; if not tolerated, consider a parenteral antiemetic. <ul style="list-style-type: none"> • Provide oral hydration if tolerated. • Use sugar-containing liquids if symptoms of hypoglycemia. • If oral intake not tolerated, consider intravenous fluids. <input type="checkbox"/> If dyspepsia ▶ Use an antacid if available in the emergency medical kit. <input type="checkbox"/> If diarrhea ▶ Use an antidiarrheal if available in the emergency medical kit. <ul style="list-style-type: none"> • If patient has fever and persistent diarrhea (>14 d), contact ground-based medical support, as local public health authorities may need to be contacted at the destination. <input type="checkbox"/> If severe abdominal pain, tenderness on examination, rigid abdomen, or blood in bodily fluid ▶ Contact ground-based medical support for additional recommendations. 	<p> STROKE-LIKE SYMPTOMS</p> <p>— Up to 5% of all in-flight emergencies —</p> <p>Initial assessment</p> <ul style="list-style-type: none"> <input type="checkbox"/> A focused history should include the time of symptom onset, specific motor and sensory components, and any other associated symptoms including headache or sensorium changes. <input type="checkbox"/> Screening for stroke: Speech disturbance, facial droop, or arm weakness. <p>Management and expected course</p> <ul style="list-style-type: none"> <input type="checkbox"/> Administer oxygen, unless saturations are known to be near or at normal levels. <input type="checkbox"/> If patient has ongoing neurological deficits suggestive of a stroke ▶ Contact ground-based medical support. <ul style="list-style-type: none"> • Recommendation may include diversion, which may not be to the closest airport if stroke care is not present at that airport. • Ground-based team should have information on capabilities for medical care near most major airports.
<p> RESPIRATORY DISTRESS</p> <p>— 10% of all in-flight emergencies —</p> <p>Initial assessment</p> <ul style="list-style-type: none"> <input type="checkbox"/> Identify history of respiratory disease, scuba diving, extremity swelling, or infectious symptoms. <input type="checkbox"/> If available, check pulse oximetry. <p>Management and expected course</p> <ul style="list-style-type: none"> <input type="checkbox"/> If ongoing dyspnea or known oxygen saturation is <95% ▶ Administer oxygen. <ul style="list-style-type: none"> • If passenger's portable oxygen concentrator fails or is not used for a patient with preexisting lung disease, consider trial of oxygen therapy. • If passenger uses ≥ 4 L/min on the ground, the onboard oxygen supply may not be enough to reverse hypoxia. • Monitor flow rate of oxygen administered; canister consumption is variable and aircraft may not have sufficient oxygen for continuous use for the duration of the flight. <input type="checkbox"/> If bronchospasm ▶ Administer albuterol, 2.5 mg inhaled. <input type="checkbox"/> If allergic reaction ▶ Refer to allergic reaction card. <input type="checkbox"/> If passenger does not improve ▶ Contact ground-based medical support for additional recommendations. 	<p> SEIZURE</p> <p>— Up to 5% of all in-flight emergencies —</p> <p>Initial assessment</p> <ul style="list-style-type: none"> <input type="checkbox"/> Identify the symptoms the passenger exhibited during the event: Including onset, duration of movement activity, quality of movements (eg, tonic-clonic), and loss of bowel or bladder function. <p>Management and expected course</p> <ul style="list-style-type: none"> <input type="checkbox"/> If unresponsive ▶ Lay passenger on floor on side, monitor airway, and assess vital signs with ongoing neurological examination as above. <input type="checkbox"/> If ongoing seizing ▶ Administer parenteral benzodiazepines if available in the emergency medical kit (not usually available on US commercial airlines). <input type="checkbox"/> If alert following a prolonged or recurrent seizure ▶ Ground-based medical support may recommend an added dose of the patient's own antiepileptic medication (if history of seizures and available) or an oral benzodiazepine (if available in the emergency medical kit). <input type="checkbox"/> If seizure resolves and patient regains normal mental status ▶ Diversion is not commonly necessary.

Figure 2. Management of Specific In-Flight Medical Emergencies: Trauma, Psychiatric, Substance Abuse, Allergy, Obstetric, and Cardiac Arrest

<p> TRAUMA</p> <p>— 5% of all in-flight emergencies —</p> <p>Initial assessment</p> <ul style="list-style-type: none"> <input type="checkbox"/> Assess all injuries for any open wounds, tenderness, deformity, or active bleeding. <input type="checkbox"/> Assess patients with injury to the head, neck, or back for any neurological symptoms. <p>Management and expected course</p> <ul style="list-style-type: none"> <input type="checkbox"/> Injuries from falling luggage ▶ Typically minor and may be assessed further at the destination. <input type="checkbox"/> Active bleeding ▶ Control bleeding with direct pressure using a gloved hand. <input type="checkbox"/> Ongoing heavy extremity bleeding ▶ Consider applying a tourniquet. <input type="checkbox"/> Suspected long bone or joint injuries ▶ Splinting material is not commonly found in the emergency medical kit, but may be improvised from available equipment (eg, a U-shaped half-rolled magazine secured with tape will make a good forearm or wrist splint). 	<p> ALLERGIC REACTION</p> <p>— 2% of all in-flight emergencies —</p> <p>Initial assessment</p> <ul style="list-style-type: none"> <input type="checkbox"/> Identify any known or likely allergen exposure; duration and severity of symptoms; and any airway swelling, respiratory involvement, or signs of systemic reaction such as generalized hives. <input type="checkbox"/> Suspected local allergic reaction: Localized pruritic rash or isolated hives. <input type="checkbox"/> Suspected anaphylaxis: Airway swelling, respiratory distress, generalized hives, hypotension, nausea/vomiting. <p>Management and expected course</p> <ul style="list-style-type: none"> <input type="checkbox"/> If local allergic reaction ▶ Diphenhydramine, 25-50 mg in adults or 1 mg/kg in children orally. <ul style="list-style-type: none"> • If unable to tolerate oral ingestion, diphenhydramine intravenously/intramuscularly at above dose. • Try a different histamine blocker if available in the emergency medical kit. <input type="checkbox"/> If anaphylaxis ▶ Epinephrine, 1 mg/mL (0.3 mL in adults, or 0.15 mL in children intramuscularly), diphenhydramine, and steroids if available in the emergency medical kit. Epinephrine may be available as an autoinjector or in an ampoule to be drawn up via syringe. <input type="checkbox"/> If there is no improvement ▶ Contact ground-based medical support for additional recommendations.
<p> PSYCHIATRIC SYMPTOMS</p> <p>— Up to 3% of all in-flight emergencies —</p> <p>Initial assessment</p> <ul style="list-style-type: none"> <input type="checkbox"/> Aim to create a rapport with the passenger to deescalate the situation. <input type="checkbox"/> Elicit information and consider the passenger's use of mood-altering substances. <input type="checkbox"/> Identify if patient takes specific psychiatric medications, dosing, last dose taken, and if available on aircraft. <p>Management and expected course</p> <ul style="list-style-type: none"> <input type="checkbox"/> If verbal deescalation ineffective ▶ Consider a benzodiazepine if available from an extended emergency medical kit. <ul style="list-style-type: none"> • Benzodiazepines are not commonly available in the emergency medical kit and are infrequently necessary even when available. <input type="checkbox"/> If combative ▶ Refer to flight crew for individual airline security protocols, which take precedence over attempts at medical management. <ul style="list-style-type: none"> • Airline security protocols vary by airline and may include restraining the passenger or diverting the aircraft for the safety of other passengers and crew. 	<p> OBSTETRIC EMERGENCIES</p> <p>— 1% of all in-flight emergencies —</p> <p>Initial assessment</p> <ul style="list-style-type: none"> <input type="checkbox"/> Identify onset and detailed description of symptoms, along with information about the pregnancy (eg, parity, gestational age, and any preceding complications). <input type="checkbox"/> Vaginal bleeding: Assess duration and severity (ie, equivalent of pads per h). <input type="checkbox"/> Labor suspected: Regular contraction, gush of vaginal fluid. <p>Management and expected course</p> <ul style="list-style-type: none"> <input type="checkbox"/> If vaginal bleeding <1 pad per h ▶ Expectant management is common. <input type="checkbox"/> If preterm labor in third trimester ▶ Place the passenger on left side and consider fluid intravenously if any concerns exist for blood loss or distress. <input type="checkbox"/> Active labor, ongoing/severe vaginal bleeding, or increasing/severe abdominal pain ▶ Contact ground-based medical support for additional recommendations.
<p> SUBSTANCE ABUSE AND WITHDRAWAL</p> <p>— Up to 3% of all in-flight emergencies —</p> <p>Initial assessment</p> <ul style="list-style-type: none"> <input type="checkbox"/> Identify type, amount, and timing of substances used. <input type="checkbox"/> Identify symptoms and mental status, along with vital signs. <input type="checkbox"/> Suspected opioid ingestion: Altered mentation, constricted pupils, respiratory depression. <input type="checkbox"/> Suspected alcohol ingestion: Altered mentation, slurred speech, behavior changes. <input type="checkbox"/> Suspected stimulant ingestion: Altered mentation, tachycardia, dilated pupils, agitation. <p>Management and expected course</p> <ul style="list-style-type: none"> <input type="checkbox"/> If normal vital signs and no respiratory compromise ▶ Observation only. <input type="checkbox"/> If suspected opioid ingestion with respiratory depression ▶ Naloxone, 0.4-0.8 mg intravenously or 2 mg intramuscularly/intranasally. <input type="checkbox"/> If suspected alcohol overdose ▶ Observe and provide antiemetic therapy. <input type="checkbox"/> If suspected stimulant ingestion ▶ Observe and hydrate (for tachycardia). Consider benzodiazepine if available from the emergency medical kit. <input type="checkbox"/> If ongoing respiratory distress or combativeness ▶ Contact ground-based medical support for additional recommendations. Refer to airline crew for individual airline security protocols. 	<p> CARDIAC ARREST</p> <p>— 0.2% of all in-flight emergencies —</p> <p>Initial assessment</p> <ul style="list-style-type: none"> <input type="checkbox"/> Check breathing and pulse; limit pulse checks to <10 seconds. <p>Management and expected course</p> <ul style="list-style-type: none"> <input type="checkbox"/> If no pulse or signs of life ▶ <ul style="list-style-type: none"> • Start chest compression-only cardiopulmonary resuscitation, with addition of bag-valve-mask ventilation (30 compressions to 2 ventilations) when the emergency medical kit is available and someone skilled is present. • Obtain and apply automated external defibrillator as soon as possible and follow instructions for defibrillation. • If no shock is advised, or AFTER a shock is delivered, resume cardiopulmonary resuscitation if there is no pulse. • If no response to cardiopulmonary resuscitation and automated external defibrillator, initiate an intravenous line. Administer epinephrine (0.1 mg/mL) 1 mg intravenously, along with consideration of causal reversible conditions such as hypovolemia and tension pneumothorax. <input type="checkbox"/> Instruct flight crew to notify the ground team and pilot if not already done. If no shock is delivered, the decision to divert will be influenced by how long ongoing cardiopulmonary resuscitation exists without return of circulation.

Considerations for Specific Conditions

Syncope or near-syncope is the most common category triggering an IME. With both benign and serious etiologies of syncope, most patients initially appear ill, have altered sensorium, and may be pale or sweaty. A common pattern is resolution after limited interventions (supine positioning, elevation of legs, and other basic care), with the passenger often improving to a normal state over 15 to 30 minutes. Initial mild bradycardia and hypotension are common during syncopal events; medical volunteers who do not commonly provide care for patients during a syncopal event may be unfamiliar with finding hypotension at the time of even benign vasovagal syncope. The key is identifying markers of etiology and need for additional interventions, such as administration of glucose or other medications.

Initial assessment of a passenger with chest pain seeks to inform the likelihood of an acute ischemic, pulmonary, vascular, or other serious medical condition. Generally, chest pain that subsides with basic onboard interventions (eg, oxygen or initial medication) is not usually caused by an acute ST elevation myocardial infarction, aortic dissection, or pulmonary embolism that would need diversion. In the event of persistent pain, abnormal vital signs, or ongoing respiratory distress, diversion is an option.

For a passenger with a possible seizure, a history of seizures or use of antiepileptic medications helps define probability of occurrence and potential recurrence. Rapid return (seconds) to a normal mental status suggests a nongeneralized seizure or vasomotor syncope rather than convulsive seizures. A few myoclonic jerks alone are not specific for seizure, as many individuals have these with syncope of any cause. If a well-described seizure stops, the passenger may remain less responsive for 15 to 30 minutes; ongoing observation is the plan for this common scenario. Single-event seizures in which the passenger recovers usually do not necessitate a diversion; multiple or ongoing seizures or failure to recover from a postictal state should prompt consideration of diversion options.

Most trauma on commercial airlines is minor and appropriately addressed with content in the emergency medical kit. Head injuries from falls or tumbling luggage are best assessed for loss of consciousness, persistent head or neck pain, scalp wounds, and any neurological symptoms. Passengers without these factors and with only minor discomfort may be rechecked later in flight or at the destination.

A variety of psychiatric symptoms may manifest on board an airplane, from simple anxiety to acute psychosis.^{75,76} Anxiety may also produce physical symptoms (eg, chest pain, shortness of breath). Patients may cause disruption and be threatening to other passengers, a challenge in the enclosed environment of an aircraft.⁷⁷⁻⁷⁹ Most cases of acute agitation or anxiety can be managed through verbal calming techniques. Consider administration of a patient's own medication if taken for anxiety and carried on board. The FAA-mandated emergency medical kit has little content that could be used for agitation.

Allergic reactions often occur in flight but are rarely serious, accounting for 1.6% of IMEs (Table 1).⁸⁰ Food-related allergies are the most common inciting cause of symptoms, especially peanuts or tree nuts,⁸⁰⁻⁸³ and other allergens may include exposure to traveling pets⁸⁴ and other environmental allergens. Specific treatment for allergic reaction includes diphenhydramine. Anaphylaxis may be

Table 4. Differential Diagnoses of Common In-Flight Medical Conditions

Medical Condition	Differential Diagnosis
Syncope or near-syncope	Vasovagal syncope, dehydration, hypoglycemia, toxic exposure, medication reaction, toxicity, acute coronary syndrome, arrhythmia, pulmonary thrombosis or air embolism, hypoxia
Chest pain	Acute coronary syndrome, pulmonary thrombosis or air embolism, pneumothorax, bronchospasm, aortic dissection, gastroesophageal reflux, musculoskeletal, anxiety
Shortness of breath	Chronic obstructive pulmonary disease, asthma, pneumonia, pulmonary thrombosis or air embolism, toxic exposure
Stroke-like symptoms	Cerebrovascular accident, transient ischemic attack, hypoglycemia, seizure, syncope, intracranial mass, complex migraine
Seizure	Seizure, syncope, hypoglycemia, eclampsia, cardiac arrest
Gastrointestinal illness	Motion sickness, foodborne illness, gastritis, enteritis, gastroesophageal reflux, pancreatitis, medication/substance withdrawal
Obstetric emergency	Preterm labor, miscarriage, ectopic pregnancy, eclampsia
Allergic reaction	Allergic reaction, anaphylaxis, cellulitis, dermatitis
Cardiac arrest	Cardiac arrest (ventricular fibrillation, ventricular tachycardia, asystole, pulseless electrical activity), syncope or other cause of collapse (see above)
Substance abuse and misuse	Misuse of or withdrawal from opioid, alcohol, benzodiazepine, or stimulant
Psychiatric issue	Anxiety, depression, grief reaction, psychosis, posttraumatic stress disorder, personality disorders, somatization

treated with epinephrine and oxygen. If available from an enhanced medical kit, corticosteroids may be administered.

Obstetric emergencies are a small proportion of IMEs (0.7%) (Table 1) but can be distressing for both the mother and the medical volunteer, who is unlikely to have experience managing obstetric emergencies. Most health care professionals recommend no flying in commercial aircraft beyond 36 weeks' gestation for single pregnancies or beyond 32 weeks for multiple gestations.⁵⁶ Vaginal bleeding or abdominal pain before 20 weeks' gestation does not typically require diversion or specific interventions during the flight beyond coordination of emergency medical services personnel on arrival. Pregnancy complications after 20 weeks' gestation or initiation of labor should prompt an urgent call to ground-based medical support to consider diversion.

For a patient with suspected cardiac arrest, resuscitate using standard cardiopulmonary resuscitation approaches.⁸⁵ Provide chest compressions at a rate of 100/min to 120/min in adults with 1 breath every 5 to 6 seconds or use compression-only cardiopulmonary resuscitation. Apply an automated external defibrillator as soon as possible. If capable, place an intravenous line and administer epinephrine, 1 mg (0.1 mg/mL) every 5 minutes. Lidocaine, 100 mg intravenously, is an option for persistent ventricular fibrillation or ventricular tachycardia in adults. Termination of resuscitation may be appropriate after 20 to 30 minutes of resuscitation without return of circulation.⁸⁶

Prevention of IMEs

The most effective way to address IMEs is to prevent them. The risk of syncope increases with dehydration in the setting of a low-humidity environment, pressure changes, and exhaustion. Travelers should hydrate often and eat scheduled meals and snacks during travel, especially with connecting or extended flights.

Physicians and nurses assisting flight travel plans for patients with chronic medical conditions should consider and educate patients on the effects of altitude, need for routine medications, and potential occurrence of medical emergencies. For example, glucometers are not part of the FAA-mandated emergency medical kit contents; a patient with diabetes should carry a glucometer, glucose supplements, and diabetes medications on board. Passengers at risk of symptomatic hypoxia need to have a portable oxygen concentrator for the flight. Multiple studies suggest that the hypoxic challenge test (exposure to 15% oxygen in nitrogen) correlates better with in-flight hypoxia than preflight oximetry, forced expiratory volume in 1 second, or the commonly used 50-m test (ability to walk 50 m).⁸⁷⁻⁸⁹ However, the hypoxic challenge test is not routine or commonly available. A reasonable estimate of need for in-flight oxygen can use published equations and a passenger's ground-level Pao₂ and Paco₂ measurements.^{90,91} Passengers with portable oxygen concentrators should have battery life that exceeds the duration of the

flight (preferably 150% of flight time) to account for unforeseen delays. Parents traveling with children should bring medications in pediatric formulations because these are not commonly available in emergency medical kits.

For patients with acute or other specific medical conditions, the International Air Transport Association recommends appropriate time intervals for fitness to travel, which are available online.⁵⁶ For other conditions, health care professionals should consult with flight and medical transport experts.

Conclusions

In-flight medical emergencies most commonly involve near-syncope and gastrointestinal, respiratory, and cardiovascular symptoms. Health care professionals can aid during these emergencies as part of a collaborative team involving the flight crew and ground-based physicians.

ARTICLE INFORMATION

Accepted for Publication: November 20, 2018.

Author Contributions: Dr Martin-Gill had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Concept and design: All authors.

Acquisition, analysis, or interpretation of data: All authors.

Drafting of the manuscript: All authors.

Critical revision of the manuscript for important intellectual content: All authors.

Administrative, technical, or material support: All authors.

Supervision: Martin-Gill, Yealy.

Conflict of Interest Disclosures: All authors have completed and submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest. Drs Martin-Gill, Doyle, and Yealy reported that they oversee the University of Pittsburgh Medical Center Medical Communications Center, which provides ground-based medical support for commercial airlines. Dr Yealy reported receipt of grants from the National Heart, Lung, and Blood Institute and royalties from McGraw-Hill, Lippincott Williams & Wilkins, and Oxford Press.

Submissions: We encourage authors to submit papers for consideration as a Review. Please contact Edward Livingston, MD, at Edward.livingston@jamanetwork.org or Mary McGrae McDermott, MD, at mdm608@northwestern.edu.

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