

In these days when physicians and their patients are often "frequent fliers," I felt that it would be helpful to our readers to be well-informed about various health-related aspects of airline travel. Dr. Gong has contributed a very informative, readable summary of current knowledge that should help you considerably in dealing with flying by you and your patients.—Burton Zweiman, MD, *Editor*.

Air travel and patients with pulmonary and allergic conditions

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Hundreds of millions of passengers fly each year aboard commercial aircraft throughout the world. Air transportation offers an efficient, safe, and, in many instances, necessary form of travel for individuals of all ages and health status. In fact, patients with diverse medical conditions now have the opportunity for increased mobility and travel, whether for business, pleasure, or health reasons. Recent advances in clinical assessment, drug therapy, oxygen supplementation, and rehabilitation programs have stimulated an interest in air travel by patients and in its health effects by physicians.¹ During the past decade, new information has been generated about commercial air travel, that is, the environmental characteristics, physiologic and medical effects, preflight evaluation, and in-flight therapy, particularly in relation to patients with chronic respiratory disorders. The temporary but unique environmental stresses presented by high-flying, pressurized, commercial jet aircraft and their management will be reviewed with special emphasis on patients with pulmonary and allergic conditions.

THE AIRCRAFT ENVIRONMENT

Physical changes

Ascent above sea level is inherently characterized by two primary physical principles that will affect, to varying degrees, the well-being of aircraft passengers. Dalton's law states that the partial pressure exerted by a gas in a mixture varies in direct proportion to its volume percent. Although the proportion of at-

Abbreviations used

BP:	Barometric pressure
COPD:	Chronic obstructive pulmonary disease
FAA:	Federal Aviation Administration
PO ₂ :	Partial pressure of oxygen
PAO ₂ :	Alveolar partial pressure of oxygen
Pao ₂ :	Arterial partial pressure of oxygen
Paco ₂ :	Arterial partial pressure of carbon dioxide
PIO ₂ :	Inspired partial pressure of oxygen
psi:	Pounds per square inch
URI:	Upper respiratory infection
ppm:	Part per million

mospheric oxygen remains 21% to approximately 295,000 feet (56 miles or 90 km) above sea level, the exponential reduction of total BP during ascent results in a significant decrease in the PO₂, even at moderate altitude, such as found aboard pressurized aircraft (Table I). For example, atmospheric PO₂ is 159 mm Hg at sea level (total BP, 760 mm Hg) and decreases to 118 mm Hg at 8000 feet (BP, 564 mm Hg) and 80 mm Hg at 18,000 feet (BP, 380 mm Hg). Physiologically, the oxygen available in the airways is further decreased because of saturation of the dry atmospheric air with water vapor (47 mm Hg) and can be calculated as inspired PO₂ (PIO₂) = 0.21 × (BP - 47). The alveolar PO₂ (PAO₂) is calculated from the alveolar air equation (PAO₂ = PIO₂ - PaCO₂/R, where R = the respiratory exchange ratio, which is assumed to be 0.8) and determines plasma PO₂ and the amount of oxygen saturation of hemoglobin. The calculated PAO₂ usually underestimates the actual PAO₂ in healthy individuals at altitude because of acute hyperventilation, which serves to increase the PO₂. The resulting PAO₂

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TABLE I. Effects of changes in cabin altitude pressurization aboard commercial aircraft

Cabin altitude		BP		Approximate PO ₂				Relative gas	
(ft) × 10 ³	(m) × 10 ³	mm Hg	psi	Cabin	Inspired	Alveolar	Arterial*	Volume	Density
0	0	760	14.7	159	149	103	98	1.0	1.0
(sea level)									
2	0.61	707	13.6	148	138	94	90	1.0	1.0
4	1.22	656	12.6	137	128	85	80	1.1	0.9
5	1.52	632	12.2	132	122	81	66	1.2	0.8
6	1.83	609	11.8	127	117	77	64	1.3	0.8
8	2.44	564	10.9	118	108	69	60	1.4	0.7
10†	3.05	523	10.1	109	100	61	53	1.5	0.7

*Values in healthy young adults.

†Cabin altitude may occasionally approach 10,000 feet for brief periods when the flight altitude is increased to avoid turbulence or adverse weather.

is modestly lower because of small physiologic shunts. Thus, the cascade of oxygen transfer from the atmosphere to the arterial blood at altitude will unavoidably result in hypoxemia during altitude ascent.

Boyle's law states that the volume of a gas varies inversely with the surrounding pressure at constant temperature. Thus, gas increases in volume and decreases in density during altitude ascent (Table I). For example, enclosed gas of 1 L at sea level will expand to 1.4 L (40% increase) at 8000 feet and to 2 L (100% increase) at approximately 15,000 feet. In contrast, gas density will decrease to approximately 70% of the sea-level value at 8000 feet and 50% at 20,000 feet. The reduced gas density decreases the resistance to turbulent air flow (which varies with the square of the flow velocity), although any decrease in the work of breathing may only be barely noticeable, even to patients with airway obstruction at the moderate altitudes present in pressurized aircraft cabins.

Aircraft pressurization

The cruising flight altitude of modern commercial aircraft ranges between 30,000 to 45,000 feet. The physical changes at these altitudes are offset to a considerable extent by multistage engine compressors that draw external air into the cabin. During flight, the environmental control unit of the aircraft extracts a portion of the compressed air and then conditions it for heating, cooling, and ventilation requirements before delivery into the cabin. An automatic pressure-control system establishes the cabin pressure as a function of altitude by regulating the outflow of cabin air by valves and maintaining a pressure differential (typically 8.6 psi) between the cabin and outside environment.^{2, 3} For example, assuming a flight altitude of 40,000 feet (atmospheric pounds per square inch, 2.7), the cabin compressor adds another 8.6 psi, re-

sulting in 11.3 psi, which is equivalent to an altitude of 7000 feet. Thus, the pressurized cabin significantly minimizes problems related to reduced PO₂ and expansion of gases and facilitates a comfortable and physiologically safe environment for the passengers who do not need supplemental oxygen. Cabin pressurization to sea level is not considered necessary for the flying public and would increase requirements for aircraft structural integrity, fuel consumption, and financial costs. Pressurization to sea level is usually not maintained once the subsonic aircraft exceeds 22,500 feet. In practice, pressurization increases linearly with (but slower than) actual altitude to the maximum differential pressure of the aircraft. Thereafter, cabin altitude increases at the same rate as flight altitude. In general, the median cabin altitude is approximately 6000 feet on both domestic and transcontinental commercial jet aircraft, although there is a wide range between different types of aircraft at the same flight altitude and in the same aircraft during portions of its flight profile.³ A trend for newer, fuel-efficient jet aircraft to be flying at higher altitudes (the FAA certifies planes to a maximum flight altitude of 46,000 feet) and the use of more recirculated cabin air than older generation planes will expose passengers to greater cabin altitudes, hypoxia, and air contaminants. A notable exception is the supersonic Concorde, which has a cruising altitude of 60,000 feet but a cabin pressurization equivalent to 6000 feet because of its relatively high differential pressure (10.7 psi).⁴

Cabin air quality

The confined environment of the passenger compartment of commercial aircraft has not been systematically studied.⁵ Experts disagree about the adequacy of cabin air quality during normal operation, in part because of the variation of environmental control sys-

tems among different models of aircraft and the lack of relevant monitoring data. The cabin air is derived primarily from compressor-delivered and recirculated air. The distribution of air within the cabin is not homogeneous.^{5,6} The ventilation rate per occupant in the first-class and business sections may be two to three times higher than in the economy or coach section. The percentage of occupied seats on a given aircraft (load factor) directly affects ventilation, since the ventilation system is relatively limited. The ventilation rate on low-load flights is much higher than when the aircraft is full, although oxygen requirements and removal of carbon dioxide are not significantly affected by even the lowest ventilation rates on aircraft.

Potentially important pollutants within the cabin environment include tobacco smoke, ozone, biologic aerosols, relative humidity, and volatile chemicals. Tobacco smoke was, until recently (1990), a significant source of passively inhaled gases (including carbon monoxide) and particulates on flights within the United States.^{5,6} However, tobacco smoke remains a potentially important health issue aboard intercontinental flights and foreign-based aircraft. Total environmental separation of the air from smoking and nonsmoking sections is not possible, especially with recirculation systems. For example, air-nicotine levels in nonsmoking areas adjacent to smoking sections may be at least as high as similar indoor areas frequented by smokers.⁶

Aircraft may encounter both stratospheric and tropospheric ozone that is maximal during spring and with increasing latitude. Although the high heat of compression of the Concorde is sufficiently high to destroy nearly all the ozone during supersonic flight,⁴ the temperature in engine compressors of other commercial jet aircraft may be inadequate to substantially reduce incoming free ozone unless catalytic converters (optional on certain aircraft) are also used.⁵ Ozone within the cabin may occasionally reach levels >0.8 ppm for several minutes, although the FAA has stated that cabin ozone concentration must not exceed 0.25 ppm (at equivalent sea-level pressure) at any time above 32,000 feet or 0.1 ppm during any 3-hour interval above 27,000 feet.

Potential biologic contaminants are viruses, bacteria, actinomycetes, fungal spores and hyphae, arthropod fragments and droppings, and animal and human dander. Outside air contains rare biologic particles during cruising altitudes, and this source is not a risk to passengers except possibly on the ground. Fungi and actinomycetes may tolerate repeated wet-dry cycles and temperature extremes within ventilation systems. Arthropod products and other nonliving anti-

gens in contaminated areas also may exist in unknown amounts. However, significant or frequent onboard infections or hypersensitivity reactions from these agents have not been reported. In contrast, certain bacteria or viruses may constitute a definite health risk from aerosolization (by coughing or sneezing passengers) or inoculation by direct contact with other passengers or fomites.⁷ Only a small proportion of infected passengers is known to airlines before travel.⁸ The risk of the spread of disease from the larger, unknown group of individuals is potentially significant. The risk is further increased when cabin air is recirculated for more than 30 minutes, such as when the occupied plane remains on the ground. Tuberculosis may be extremely contagious under such conditions. An unusual epidemic of influenza occurred aboard one crowded plane grounded for 4 hours and without fresh outside air ventilation.⁹ There is no evidence that the human immunodeficiency virus can be transmitted through the air or by casual human contact.¹⁰

In most aircraft, fresh air is brought in from outside through the engines, cooled, and delivered to the cabin without humidification. At room temperature, the cabin humidity is usually 10% to 20%.⁵ The low relative humidity may decrease the survival of bacteria and house dust mites (*Dermatophagoides*)¹¹ but not necessarily viral viability. Low relative humidity may facilitate bronchoconstriction in some individuals with asthma and drying of respiratory secretions in patients with chronic bronchitis, bronchiectasis, or tracheostomy. Disinfectants and cleaning chemicals used on aircraft can also be a source of health problems for some passengers, although no data are available regarding their concentrations in cabins during operation. The best cabin-air quality would be achieved with fresh-air ventilation of the entire cabin^{5,6} and filtering of any recirculated air. However, the efficiency of ventilation filters is unknown.

PASSENGER RESPONSES

Healthy individuals easily tolerate the acute altitude changes aboard pressurized aircraft.¹² The hypobaric hypoxia at a cabin altitude of 5000 to 8000 feet usually results in a P_{aO_2} ranging from 55 to 70 mm Hg at rest¹³ (Table I). Hyperventilation is the first response of the body to acute hypoxia and is initiated when the P_{aO_2} falls below 60 mm Hg, although there is substantial individual variability. The alveolar-arterial oxygen gradient usually narrows with hypoxia. Other acute physiologic responses are tachycardia, increased cardiac output with preferential redistribution to the heart and brain, and hypoxia-induced pulmonary vasoconstriction.

Patients with preexisting abnormal gas exchange

may have decreases in resting PaO_2 to as low as 30 to 40 mm Hg at the same moderate altitudes.¹³⁻¹⁵ The decrease in oxygenation is a function of (1) underlying pathophysiologic disturbances in the lungs (i.e., ventilation-perfusion mismatching, right-to-left shunting, and mixed venous PO_2), which determine ground-level and altitude PaO_2 , and (2) the final cabin altitude reached, which determines the maximum available oxygen in the air. In addition, patients with pulmonary conditions, such as COPD or neuromuscular disorders, may not be able to hyperventilate because of mechanical limitations and/or diminished hypoxic ventilatory drive. Thus, their arterial oxygenation will worsen. Other hypoxia-promoting factors may hinder adequate ventilation or tissue oxygenation, such as worsening of preexisting pulmonary hypertension, anemia, carboxyhemoglobinemia (from preflight smoking or on-board smoke exposure during intercontinental flights), exercise, sleep, sedatives, alcohol, and fatty foods (which increase carbon dioxide production).¹² Subjectively, many patients with chronic hypoxic lung disease apparently tolerate the altitude-induced hypoxia without supplemental oxygen, as long as they remain at rest. Some patients may sense easier work of breathing with the less dense air. However, this small advantage is largely negated by the significant decrease in atmospheric oxygen. Even light exercise (such as arm movements or walking in the aisle) will significantly increase oxygen requirements and produce limiting dyspnea, fatigue, and light-headedness or dizziness. Asymptomatic cardiac arrhythmias may also occur at rest during acute hypoxemia.¹⁵ Altitude tolerance may be particularly poor in patients with borderline hypercapnia, cerebrovascular and/or cardiac disorders, or anemia while they are at sea level. Patients with stable asthma generally tolerate the moderate cabin hypoxia as long as adequate bronchodilator therapy (with or without corticosteroids) is used.

The expansion of unvented or entrapped gases with altitude ascent may worsen ventilation and gas exchange in patients with lung bullae or blebs.¹² Poorly communicating air units or mucus plugging may predispose the patient to expanding space-occupying bullae and, with coughing, to pulmonary barotrauma, resulting in free mediastinal air or pneumothorax. The latter can have serious or fatal sequelae should a tension pneumothorax develop during flight. Significant abdominal distension from expansion of air in the intestinal tract may also restrict lung expansion. Pneumatic devices such as cuffed endotracheal tubes are susceptible to pressure changes.

The aircraft usually changes at 500 ft/min during ascent and 300 ft/min during descent to minimize

rapid pressure alterations.⁵ However, these transitional changes in BP frequently affect air-containing paranasal sinuses or the middle ear in many passengers, regardless of pulmonary status.¹⁶⁻¹⁸ Ascent expands the intraluminal gas within these rigid-walled cavities, and the relative positive pressure leads to asymptomatic venting of the gas through sinus ostia or eustachian tube and equalization of pressure between the cavity and the surrounding atmosphere. Obstruction of the venting passages may be related to URI, or allergic rhinitis (accompanied by local inflammation, edema, or mucus), or structural defects. During descent, gas exit is blocked by the relative negative pressure within the cavities and the physical obstruction, resulting in a pressure differential of 100 to 200 mm Hg between the middle ear and ear canal at sea level. Symptoms are decreased hearing, ear fullness, and/or progressive pain. The passive opening of the nasopharyngeal portion of the eustachian tube (which functions as a one-way flutter valve) must be opened to equalize the pressure between the middle ear and the atmosphere. This may be achieved by actively constricting the tensor palatine muscles, for example, by swallowing, yawning, sucking, or moving the lower jaw from side to side, or by pressurizing (autoinsufflation) the nasopharynx, that is, a Valsalva maneuver. Topical vasoconstrictive sprays or drops (e.g., pseudoephedrine) or an oral decongestant decreases mucosal edema and facilitates the egress of air. Sleeping during descent may worsen the situation, since swallowing is then infrequent.

EPIDEMIOLOGIC INFORMATION

Data about the frequency and types of medical emergencies or problems in passengers during commercial air travel are largely unavailable or inaccurate, since published estimates or surveys are based on anecdotal accounts or medically unsupported reports from various parties.¹ The follow-up or outcome of passengers with in-flight medical problems are unknown. It is suspected that many passengers with significant health problems are reluctant to report their ailments (if they are known) and do not alert their physician or the airlines about their health status. Nevertheless, recent surveys¹⁹⁻²¹ of in-flight emergencies consistently list shortness of breath, hyperventilation, chest pain, and neurologic or mental status changes as the most common symptoms. Clinically significant exacerbations of occult or known cardiopulmonary disease and unexpected cardiac-related deaths are prominent findings in recent surveys. For example, 260 passengers (0.003%) of 8.7 million passengers arriving at Los Angeles international airport during a 6-month period developed in-flight medical com-

plaints.²¹ Seven passengers died in flight from fatal cardiac arrest (six passengers) or cerebrovascular accident. Another 123 passengers were triaged to a local emergency care facility, where syncope or seizure (14 patients), gastroenteritis (13), COPD exacerbation (12), and unstable angina (11) were the most frequent diagnoses. Twenty-five patients were admitted to the hospital, and eight were discharged with cardiopulmonary diagnoses and three patients with a cerebrovascular-related diagnosis. The hypoxemia of altitude can only be speculated to have been a contributing factor in these situations. The incidence of pulmonary embolism may be considerably underestimated in passengers flying long distances in economy class, since many do not manifest their symptoms until after arrival.²² Thus, flight-related medical illnesses probably occur more frequently than reported or believed, although true emergencies appear to be rare during flight.

Foreign carriers have equipped their aircraft with doctors' kits containing relevant emergency medications and equipment for more than a decade.²³ In 1986 the FAA required additional medical supplies (in the form of an enhanced medical kit) to be aboard all American aircraft capable of carrying 30 or more passengers.²⁴ The minimum contents of the medical kit are a stethoscope, sphygmomanometer, oropharyngeal airways, needles and syringes, epinephrine (1:1000), nitroglycerin tablets, 50% dextrose, and injectable diphenhydramine. Any use of the kit requires a written explanation about the indications and circumstances. Data²⁵ from the first year of the regulation indicated that the kit was used for 362 passengers during 361 flights of one major commercial airline and predominantly for syncope/near syncope (63 passengers), cardiac/chest pain (34), asthma/lung disease/shortness of breath (22), seizures/anxiety (17), allergic reactions (10), and hyper- or hypoglycemia (six). Although the true benefits of the kit (such as reducing mortality or flight diversions) remain to be determined, the required basic data collection will undoubtedly shed more light about the incidence and types of medical problems experienced aboard commercial flights as well as the efficacy of the current kit. One important deficiency of the kit is the lack of an aerosolized bronchodilator.^{20, 25}

PREFLIGHT EVALUATION

Physicians and other health-care providers may be asked by concerned patients and airlines about an individual's tolerance and safety for air travel. Until recently, preflight evaluation was based largely on the patient's previous flight history, clinical stability, results of routine laboratory tests, and the clinical judg-

TABLE II. Relative* and absolute contraindications for commercial air travel

Conditions adversely affected by hypoxia
Active bronchospasm
Cyanosis
Dyspnea at rest or during exercise
Active URI or lower respiratory infection, especially tuberculosis
Thrombophlebitis, pulmonary embolism
Pulmonary hypertension, with or without cor pulmonale
Severe anemia (hemoglobin <7.5 gm/dl)
Sickle cell disease
Seizures or cerebrovascular disease
Angina pectoris, congestive heart failure, arrhythmia, myocardial infarction (within 3 to 4 weeks)
Inadequate lung function
Vital capacity <50% predicted
Maximum voluntary ventilation <40 L/min
Diffusing capacity <50% predicted
Hypercapnia (PaCO ₂ >50 mm Hg)
Hypoxemia (PaO ₂ <55 mm Hg) on room air
Conditions adversely affected by pressure changes
Noncommunicating blebs or bullae
Pneumothorax or pneumomediastinum†
Thoracic surgery (within 3 weeks)
Otitis media, sinusitis, recent middle ear surgery

*Most conditions are relative contraindications since they may be partially improved or corrected by supplemental oxygen, medications, or time for healing or rehabilitation.

†Absolute contraindication.

ment of the advising physician. The latter factor remains essential but can now be supplemented with objective, physiologic assessment. Unfortunately, clinical stability and unremarkable or borderline test results on the ground may be relatively unreliable and poorly predictive of what can occur during acute exposure to moderate altitude. Patients with unremarkable previous flights may have occult cardiac arrhythmias and borderline tolerance to hypoxia, mobility, and other stresses of flight. Relative and absolute contraindications to air travel are summarized in Table II. Chest radiographs may indicate chronic changes of hyperinflation or interstitial fibrosis as well as lung bullae or blebs (and, occasionally, a pneumothorax), which would alert the physician that the patient has increased risk for altitude-related hypoxemia and/or barotrauma. Pulmonary-function results are also important preflight indicators of in-flight tolerance (Table II).

The PaO₂ at ground level (measured as close as practically possible before flight) is probably the best predictor of altitude tolerance because hypoxia is the

most clinically relevant and frequent stress for patients with pulmonary disease at altitude.^{1, 15} An altitude PaO_2 of ≥ 55 mm Hg is generally considered a reasonably safe threshold level (with an oxygen saturation $>85\%$ to 90%), although oxygenation may decrease further with modest exercise. The arterial oxygenation of patients with stable, normocapnic COPD at moderate altitudes has been evaluated with hypoxic gas mixtures, hypobaric simulation, and actual air flight.¹³⁻¹⁵ The altitude PaO_2 before flight may be reasonably predicted in patients with COPD up to 10,000 feet according to the regression equation¹⁵ altitude $\text{PaO}_2 = 22.8 - 274x + 0.68y$, where x = altitude in thousands of feet and y = sea-level PaO_2 . The use of FEV_1 (as percent predicted) may enhance the prediction accuracy of the in-flight PaO_2 at 8000 feet in patients with COPD¹³: PaO_2 at 8000 ft = $0.45y + 0.78 (\% \text{ FEV}_1) + 2.44$.

These regression equations are helpful to predict the oxygenation status of patients with COPD and the possible need for supplemental oxygen at altitude. Another objective, more comprehensive preflight evaluation, is a hypoxia-altitude simulation test¹⁵ that has the patient breathing hypoxic gas mixtures equivalent to the atmospheric oxygen at 8000 feet (i.e., the "worst-case" cabin pressurization, excluding accidental acute decompression) or other cabin altitude. Thus, 17.1% and 15.1% oxygen are equivalent to the atmospheric oxygen available at 5000 and 8000 feet, respectively. This type of testing can be performed in conjunction with pulse oximetry (or arterial catheterization) and electrocardiographic monitoring in many pulmonary-function laboratories and can directly assess the patient's symptomatic responses, tolerance to exercise, amount of supplemental oxygen required, and the effects of controlled hypoxia on concomitant hematologic, cardiac, and neurologic disorders. These data are not provided by the prediction of altitude PaO_2 alone.

PREFLIGHT PREPARATIONS

Patients who are found to be able to fly safely aboard commercial aircraft may or may not require certain precautions and medical assistance. For example, patients should be advised to carry onboard all prescribed medications for uninterrupted and/or as needed use. Patients with respiratory problems should always carry their bronchodilator(s), corticosteroids, nonsedating antihistamines, antibiotics, and other medications. A supply of decongestants is highly recommended for passengers recovering from an URI or who have chronic sinus or ear disorders. Decongestants should be taken 15 minutes before descent. In all cases the patient must have an adequate supply of medications during the entire travel itinerary. Patients

found to be medically unstable or inappropriate for commercial air travel can still be flown on an air ambulance.

In-flight supplemental oxygen is probably the most important provision that requires advance planning and which can ensure a safe flight for hypoxemic patients.^{12, 26} On-board oxygen must be supplied by the airlines, which must be alerted to this additional service at least 48 hours before departure. The physician may be contacted by the airline for an oxygen prescription as well as a verbal or written medical clearance. Personal oxygen units cannot be used on-board by patients and, if these are transported, must be essentially emptied and checked in as baggage. Oxygen is not supplied for continuous or intermittent use (except for emergencies) by all airlines. This aspect has been frustrating for many patients and their healthcare advocates, since the airlines are not required to electively provide oxygen and since carrier policies differ widely regarding their capability to provide oxygen. When oxygen is supplied, it is usually delivered at 2 or 4 L/min by mask from oxygen cylinders. Different flow rates must be arranged in advance but are not available on all airlines. The patient should also be aware that oxygen may be needed at stopover points and at the final destination. These arrangements are not the responsibility of the carriers. Thus, the oxygen-dependent patient should probably arrange oxygen supplies through a national vendor as well as schedule direct flights as much as possible.

IN-FLIGHT PHYSICIAN ROLE

Physicians who fly on commercial airlines should be aware of their potential role during medical emergencies. The commercial carriers rely a great deal on volunteer physicians when an in-flight medical emergency arises, since physicians are frequent fliers and since they offer medical assistance on 8% to 43% of flights.^{19, 21} Commercial airlines and their flight crews in the United States are not legally obligated to tend to the medical needs of the passengers.^{2, 27} The primary responsibility of the flight attendants is passenger safety and, if this becomes necessary, evacuation from the aircraft. Other services (e.g., serving refreshments) are ancillary functions. The amount and quality of first aid and basic life-support training of the attendants varies markedly from airline to airline. Few airlines provide certification or retraining protocols. U.S. flight attendants cannot legally diagnose or administer medications in flight.²⁰ Their understanding of supplemental oxygen systems and therapy is minimal, at best. Some physicians^{19, 20} have advocated special training of selected senior flight attendants to the level of a basic emergency medical technician who can also operate automatic external defibrillators. This

action would be impractical and generate significant liability risks from the viewpoint of the airlines.

In the United States, physicians are under no legal obligation to volunteer medical aid, although they may be in other countries (e.g., France). A federal "good Samaritan" law does not yet exist, and legal protection is unclear. However, most physicians will likely have a moral obligation to assist in an in-flight medical emergency.²⁷ It is anticipated that professional liability is nil as long as the ill passenger is not billed for services rendered and the medical aid was of a standard compatible with the physician's training.^{27, 28} Legislation at the federal level is sorely needed to protect physicians who in good faith render emergency medical care during flight.

Unlike examining or emergency rooms, the aircraft cabin represents a confined, noisy environment that is isolated from routine ground-based services. The volunteer physician will usually encounter great difficulty in performing worthwhile stethoscopic auscultation of cardiovascular sounds because of inherent vibrations and background noise. Some physicians^{19, 20, 25} have argued for additional therapeutic options, such as a diuretic, diazepam, morphine sulfate, β_2 -agonist, and automatic external defibrillator. However, the more medical supplies, equipment, and training of the flight crew, the greater potential for liability because the airlines would then be assumed to offer a higher standard of medical care.²⁸ Other practical considerations are the costs, maintenance, and security of the new additions. In the final analysis, the assisting physician will have several options²⁷: (1) management of the emergency with available supplies and equipment and priority landing at the scheduled destination, (2) recommendation that the pilot descend to 22,500 feet (altitude at which the cabin will be at sea level) if supplemental oxygen is not helpful, (3) ground radio contact for medical consultation, and/or (4) request that the pilot divert the plane to the nearest airport with awaiting ambulance. Appropriate triage decisions in the air can prevent many unscheduled landings,²⁰ thereby minimizing expense, inconvenience, and risks to the crew and other passengers.^{2, 20}

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