Current Practice

Transport of Invalids by Air

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General practitioners not infrequently are uncertain whether a patient is fit to travel by air. This article is based on a guide prepared to advise in general terms on the principal factors to be considered. The first guide was prepared some years ago, but it has since been revised on several occasions, the last time being by the Medical Committee of the Aerospace Medical Association.

Introduction

The number of persons travelling by air increases every year, and included in that total is an appreciable number of invalids suffering from illnesses of varying degrees of severity from the slightly indisposed to those near the end of a terminally fatal disease.

Sick persons, including those at both extremes of the age scale, tolerate modern flying conditions with very little, if any, discomfort. The number of invalids wishing to travel by air who have to be refused passage is steadily decreasing, and the great majority of cases benefit by the advantages air travel has to offer over surface travel, including speed, smoothness, and comfort. In many cases this form of transport is not merely desirable but actually life-saving.

Aircraft

Cabins.—All modern aircraft have pressurized cabins, the advent of which has greatly simplified problems of oxygen

atmospheric pressure (14.7 lb. per sq. in.), and it is this factor which is chiefly responsible for the few specific contraindications to air travel. The slightly lowered air pressure means that the air density in the cabin is somewhat reduced, and that therefore a little less oxygen is present in the inspired air than is the case at sea level. In most modern aircraft the cabin air pressure is maintained at an equivalent of 6,000 ft. to 8,000 ft. (Table I).

Fig. 1 shows the fall in the oxygen tension in the lung alveoli as cabin altitude increases. Fortunately, the high affinity of haemoglobin for oxygen means that arterial oxygen saturation does not fall proportionately rapidly. As Fig. 2 indicates, a

FIG. 1

FIG. 2

TABLE I.—Effects of Cabin Pressurization

Aircraft	Con-corde	Boeing 747	VC-10	Boeing 707	DC-8	Tri-dent	Comet 4	BAC 111	Cara-velle
Maximum differential pressure lb./sq. in.	10.7	8.9	9.0	8.6	8.77	8.25	8.75	7.5	8.25
Actual and cabin altitudes (ft.)									
60,000	6,000								
40,000	2,400	6,200	6,100	7,100	6,700	7,900	6,700	9,800	7,900
35,000	1,000	4,700	4,500	5,400	5,000	6,100	5,000	8,000	6,100
30,000	S.L.	2,700	2,600	3,400	3,000	4,100	3,000	5,800	4,100
25,000		600	400	1,300	900	1,900	900	3,400	1,900
22,500		S.L.	S.L.	S.L.	S.L.	700	S.L.	2,100	700
20,000								800	S.L.
17,500								S.L.	
15,000									

S.L. = Sea level.
It is normal practice to operate at cabin altitudes 300–500 ft. higher than those stated above in order to give smoother cabin altitude control.

supply, though it has brought a number of other problems in its train. Briefly, the principle of pressurized cabins is to introduce air by means of a mechanically driven impeller, so that a controlled pressure is maintained in the cabin of the aircraft irrespective of the ambient atmospheric pressure. Aircraft design requirements make it necessary for the pressure in an aircraft to be slightly lower than the normal sea-level

cabin altitude of 5,000 ft. leads to a fall in arterial oxygen saturation of only 3% below the ground-level normal of 96%. This slight degree of hypoxia may affect patients with significantly impaired cardiovascular or respiratory reserves, and such individuals should accordingly not travel by air without prior consultation with the medical department of the airline concerned, when special arrangements can be made to supply supplementary oxygen for individual cases.

Operational Characteristics.—It is sometimes helpful to know the operational characteristics of the aircraft in which the patient will fly—although nowadays conditions in the cabin are so regulated both as to actual conditions and rate of change

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TABLE II.—Typical Aircraft Comparative Data

Aircraft	Boeing 707-436	Vickers Super VC10	Caravelle VIN	BAC 1-11 300	Trident I	Douglas DC-9-30	Concorde
Take off distance sea level (ft.)	11,000	9,050	6,200	7,150	7,900	7,300	9,650
Max. take off weight (lb.)	311,750	335,000	105,820	87,000	115,000	108,000	350,000
Take off speed at max. take off weight (m.p.h.)	183	181	153	146	164	—	230
Typical initial rate of climb (ft./min.)	2,500	2,500	2,500	2,500	2,900	3,000	3,300
Typical cruise speed (m.p.h.)	545	545	510	540	580	560	1,320
Normal operating altitude (ft.)	30/40,000	30/40,000	25/30,000	25/30,000	25/31,000	25/35,000	50/65,000
Typical average rate of descent (ft./min.)	1,500	2,000	2,400	2,000	2,100	2,000	2,400
Range, average statute miles	3,650	3,550	1,325	820	870	780	3,800
Average capacity (lb.)	44,600	43,500	17,100	21,600	19,000	24,300	25,000
Landing distance at max. landing weight (ft.)	7,800	6,250	5,300	5,560	6,260	4,850	8,450
Landing speed at max. landing weight (m.p.h.)	168	159	145	143	160	146	175
Max. passenger capacity	162	157	90	79	100	107	120
Cabin differential (lb./sq.in.)	8.6	9.0	8.1	7.5	8.25	7.46	10.7

that no doctor need fear for his patient's safety. As a matter of interest operational data of some current aircraft in common use are given in Table II.

An essential component of all large passenger aircraft is emergency oxygen equipment which comes into use automatically in the event of an emergency, when the cabin pressure falls for one reason or another. In addition, when a patient requires oxygen an invalid oxygen set can be put on board for his exclusive use. Fittings for stretcher cases are to be found on most large passenger aircraft.

All aircraft have seat belts, and seat backs and fittings are constructed so that in the event of an emergency landing or severe braking injury to passengers is minimized.

Finally, all airlines carry first aid kits for use should they be required.

Cabin Staff.—A proportion of air stewardesses are State registered nurses and all cabin staff have training in elementary first aid and care of the sick.

Consequences of Atmospheric Change

Apart from specific disabilities it is important to know of certain conditions which can be brought about by the changing physical environment of flight on ascent and descent. They may be of no concern to the passenger, or cause merely passing discomfort; in some cases they may produce disabling pain. The group heading under which the commoner conditions are included is known as dysbarism. The commoner manifestations met with in flying are described below.

Otitic Barotrauma or Barotitis Media.—This is caused by failure to equalize pressure in the middle and outer ear as atmospheric pressure rises when the aircraft descends, leading to tension and varying degrees of trauma to the tympanic membrane. It can vary from dull transient earache to severe disabling pain. It is brought about by lack of patency of the eustachian tube usually due to nasopharyngeal infection.

Sinus Barotrauma or Barosinusitis.—This condition is brought about by similar conditions, namely inadequate ventilation of a sinus resulting in a pressure gradient—the pain is caused by air trapped in the sinus expanding. It is very sharp and sudden in onset and has been likened to a blow on the head with a hard instrument.

Aeroembolism.—This is very rarely met with in pressurized cabins. Pain in the joints is caused by release of nitrogen into the tissues. It is relieved by the administration of oxygen.

Aerodontalgia—is toothache brought on by expansion of gas in a badly filled cavity. It is rare.

Expansion of gases—whether in the gut or the thorax can lead to discomfort and in some cases severe pain. It is usually of no clinical significance, but in the thorax it can lead to serious conditions such as mediastinal shift (Figs. 3 and 4).

Hypoxia.—As stated earlier, pressurized cabins maintain an atmospheric pressure approximately equivalent to 8,000 feet at whatever altitude the aircraft may be flying. There is therefore a small degree of hypoxia. Any patients with a decrease of the pulmonary ventilating area or coronary deficiency may

experience exaggerated symptoms for which personal emergency oxygen should be provided.

Motion Sickness.—This is very rare in modern jet flying, which is usually above bad weather—but there are three occasions when it may occur, namely clear air turbulence, when descending through bad weather to airports, or when delayed in the airport circuit while other aircraft are landing. Such transient sickness can be effectively dealt with by well-known remedies with a hyoscine content, in addition to such measures as loosening constrictive collars, lying in the recumbent position, and avoidance of overheating. Severe attacks must be carefully watched in the case of diabetics or recent peptic perforation, but such episodes are very rare.

Assessment of the Patient

General basic principles should be considered before a patient flies.

(a) Is he fit to travel by any means of transport? If the answer is "no," further consideration of air travel can be ruled out.

FIG. 3.—Radiographs showing pneumothorax at 1,000 ft. (A) and 10,000 ft. (B) respectively.

FIG. 4.—Radiographs showing expansion of intestinal gases under lowered conditions of atmospheric pressure. A, Ground level; B, 40,000 ft.

(b) Is he fit to travel with other members of the public? There are certain cases which for reasons of public policy cannot be carried in a public transport vehicle. In public transport aircraft aesthetic considerations and the comfort of the other passengers demand that a patient should look and smell normal and behave normally. If these requirements cannot be met a private charter aircraft should be considered. The first type of case of this sort which cannot be carried is that which either in appearance or odour is objectionable to fellow passengers. Such cases include open wounds or lesions of exposed parts, such as the face, a colostomy over which the patient has little or no control, grossly disfiguring conditions, or incontinence of urine or faeces. It should be remembered that a colostomy over which an individual has control at ground atmospheric pressure may well become uncontrollable in conditions of lowered pressure. Patients with carcinoma at times have an extremely unpleasant smell and in the confined space of an aircraft cabin can be most objectionable. Secondly, cases should be refused which by reasons of their behaviour are objectionable to other occupants of the aircraft. Such cases would include those prone to extreme noisiness, peculiarities of habit, incontinence, or major epilepsy, and cases of mental illness when not accompanied by an attendant or suitably sedated.

(c) The stability of the patient's condition should be considered. It should be ensured as far as possible that there is not likely to be a medical crisis en route necessitating diversion of the aircraft from its prescribed course. Apart from the great inconvenience and cost caused it can in certain cases, as for example long trans-oceanic flights, imperil the safety of the aircraft. It should be possible to ensure against the likelihood of this with a fair degree of certainty.

Contraindications for Acceptability

Cardiovascular

Cases of uncompensated heart disease and severe angina pectoris should not travel by air unless special arrangements are made and extra supplies of oxygen are available. Unhealed coronary thrombosis is a contraindication to air travel. At least two to three months should have elapsed since the acute episode, and if there are residual symptoms the medical department of the airline should be consulted.

Cases of controlled hypertension will normally be accepted without restriction, but the value of a sedative before flight should be remembered. Where there is evidence of cardiac, ocular, or renal complications, the airline medical department should be advised.

Persons who exhibit cyanosis, severe disturbance of rhythm, persistent arrhythmias resulting in recurrent prostration, syncope, or shocklike conditions, those with markedly enlarged hearts, extreme valvular stenosis, convalescent myocardial infarction, marked exertional angina, severe hypertension and hypertensive encephalopathy, or any other condition which restricts the cardiac reserve to such an extent as to render the patient unable to climb one flight of stairs without production of symptoms or severe dyspnoea should be carefully evaluated before they are advised that air travel is safe for them.

A patient with a history of thrombotic or venous disease should be instructed against remaining immobile for long periods during air flight. Immobility and the associated venous stasis in the limbs are believed to be important factors in the development of "passenger phlebitis," which may result in pulmonary infarction.

Blood Dyscrasias

Flying is contraindicated in blood dyscrasias where the red cell count is less than 2.5 million/mm., or the haemoglobin

less than 50%. If a blood transfusion is given, the aim should be to raise the haemoglobin to over 60% before flight. All cases of blood dyscrasia other than simple mild anaemias should be referred to the airline medical department because of their known liability to symptoms from minor degrees of oxygen lack. Acute leukaemias which have recently been treated with x rays constitute a contraindication to air travel on account of the possibility of haemorrhage under conditions of lowered oxygen tension.

Respiratory

Acute upper respiratory tract infections.—The common cold, sinusitis, and pharyngitis may cause blockage of eustachian tubes and sinus foramina. Inability to ventilate the middle ears and sinuses to compensate for pressure changes during climb and descent may cause severe pain, and patients with these disorders should postpone their flight until the condition has subsided. It should be remembered that chronic naso-pharyngeal conditions in which the patency of the eustachian tubes is impaired can give more trouble than the acute phase when congestion is not so marked.

Asthma and bronchitis.—Sufferers from asthma, chronic bronchitis, and emphysema should be assessed for the degree of respiratory embarrassment present, and the value of a sedative should be remembered. The uncontrolled coughing and copious offensive sputum which may be produced in cases of severe bronchiectasis may make patients with the condition unacceptable in spite of reasonable respiratory efficiency.

Tuberculosis, Pneumothorax, etc.—Respiratory disorders affecting exercise tolerance should be considered in a similar manner to cardiovascular diseases, and where there is any doubt the attending physician should make special arrangements with the airline medical department. Cases of active pulmonary tuberculosis must be considered to be potentially infective under conditions of reduced air pressure and cannot therefore be accepted. Quiescent or healed cases may travel without restriction. If an artificial pneumothorax is present, seven days must have elapsed since the last refill and the lung must be at least three-quarters expanded, because of the effects of reduced pressure on trapped gas.

Apart from the question of reduction in the available area of lung tissue, another important factor is the possibility of mediastinal or diaphragmatic shift (Fig. 3) as a result of operation or disease. Such a condition would be aggravated under changed conditions of pressure, and where such a liability exists flying should be avoided.

Persons whose vital capacity is 50% or less do not do well in unpressurized aircraft unless a flight altitude of less than 5,000 feet is maintained. Pulmonary function and reserve should be evaluated in order to determine whether persons with pulmonary emphysema or severely limited ventilation, arising from pulmonary fibrosis, should travel by air.

Gastrointestinal

The reduced cabin air-pressure allows intestinal gas to expand. Resulting distension means that flying is contraindicated in patients who have recently undergone abdominal operations—10 days post-operation being the minimum acceptable time after uncomplicated appendicectomy, etc. The risk of perforation and haemorrhage from this cause in patients with active peptic ulceration means that the airline medical department must be consulted in these cases prior to flight. Trained colostomy patients may fly provided that they are well acquainted with measures for the control of their colostomy, which is likely to be more active in the air. In all such cases any increased tendency to vomit must be watched and control measures taken.

Infection

Cases of infectious diseases, including poliomyelitis and trachoma, cannot of course travel in public transport aircraft. Special arrangements can usually be made for the carriage of poliomyelitis cases after the acute and infectious stages have passed.

Neuropsychiatric

The safety of the other passengers and crew should be evaluated when a person with a psychiatric disorder is being considered for travel by air. Persons manifesting unpredictable behaviour or those who require heavy sedation or restraint should not fly on commercial transports. However, the judicious use of medication should reduce the incidence of neuropsychiatric problems.

Age

Old people with well-compensated cardiovascular and respiratory systems tolerate air flight excellently. There are no contraindications to flying based on advanced age alone. Equally, the newly born tolerate air travel well and there are no lower limits to such cases.

Central Nervous System Disorders

Most of these cases are covered by the "look and smell normal, and behave normally" rule. Uncontrolled epilepsy and faecal or urinary incontinence would therefore be absolute contraindications to travel in public transport aircraft. It must be remembered that epilepsy is aggravated by mild hypoxia and hyperventilation. Cases of Parkinson's disease, for example, could be carried by special arrangement, and cases of mental disorder might be accepted under sedation, or if accompanied by an attendant.

Patients who have had poliomyelitis are acceptable for air travel provided one month has elapsed since the onset of the disease, the disease generally being considered to be non-infectious after such a period. If the patient is not ambulatory a special attendant is required. Occasionally special arrangements can be made with some airlines to transport persons recovered from the bulbar type of poliomyelitis. In this type of case preparation must be made by the airline concerned to have the proper power supply (correct voltage and wattage) for activation of the portable respirator, if this apparatus is required.

Metabolic Disorders

Diabetes is not a contraindication to air travel provided the patient is well stabilized, severe cardiovascular disease is absent, and the individual is instructed concerning the importance of feeding at physiological intervals rather than being guided by local times, which can change by several hours in flying. Oxygen should be available in these cases, because they are particularly sensitive to hypoxia. Appropriate preventive measures should be taken if the patient is liable to motion-sickness.

Airsickness is, however, rare nowadays in aircraft which fly at high altitudes, because less turbulence is encountered. It has been found by experience that remedies containing hyoscine in a dosage of 1/100 gr. (0.6 mg.) constitute the best routine prophylactic for adults.

Pregnancy

The majority of international airlines carry pregnant women up to and including the 32nd week of pregnancy, and this may be extended on domestic services. The restriction is introduced in order to avoid, as far as possible, the risk of

birth while airborne. If a passenger is known to be prone to abortion flying may be contraindicated up to the third month of pregnancy. In this connexion it should be remembered that though weather conditions may be good at the beginning of a flight they may deteriorate en route and extreme turbulence may occasionally be encountered. This might result in premature and precipitate labour.

Terminal Stage of Life

There is no contraindication to patients near to death flying, but patients *in extremis* should not be accepted for air travel because of the difficulties associated with deaths en route.

TABLE III.—Summary of Restrictions on the Carriage of Invalids

Condition	Limiting Factors	Restrictions and Precautions
Anaemias Blood dyscrasias Reticuloses	Red cell count below 2½ million per cu.mm. Haemoglobin below 50% Severe involvement of mediastinal lymph glands Severe constitutional upset Radiation sickness Tendency to haemorrhage	Airline medical department must be consulted Haemoglobin should preferably be raised to 60%, by transfusion if necessary Oxygen must be available
CARDIOVASCULAR DISEASES		
A. Angina pectoris Compensated heart disease	Reasonable threshold for exercise without symptoms	Airline medical department should be notified Oxygen must be available
B. Uncompensated heart disease	Evidence of failure	Each case must be considered on its merits
C. Coronary occlusion	Minimum of 8–12 weeks post-occlusion. If residual symptoms are present, case must be treated as A or B above	As A or B above
D. Hypertension: (i) Controlled and asymptomatic (ii) Complicated	Impairment of cardiac, renal or C.N.S. function	Sedative may be indicated. Airline should be notified Airline medical department must be consulted Oxygen must be available
RESPIRATORY DISEASES		
A. Acute upper respiratory tract infections	Eustachian or sinus catarrh	Air travel temporarily contraindicated
B. Asthma, bronchitis, emphysema, and non-infectious fibrotic diseases	Exercise tolerance only moderately impaired	Airline medical department should be notified Oxygen must be available If exercise tolerance is severely impaired, special arrangements must be made
C. Pulmonary T.B. (i) Active (ii) Quiescent or healed	Tubercle bacilli in sputum Degree of impairment of function	Cannot be carried while regarded as infectious As B above. Seven days must have elapsed since refill of artificial pneumothorax or pneumoperitoneum. Lung must be ½ expanded
D. Pneumonia	Must be resolved. Residual impairment of function	As B above
E. Bronchiectasis	(i) Impairment of function (ii) Copious offensive sputum	As B above Cannot be carried, except by special arrangement
GASTROINTESTINAL DISEASES		
A. Peptic and bowel ulceration (i) Active	May bleed or perforate under reduced pressure, or be aggravated by motion sickness Should not travel within 3–4 weeks of haematemesis or melaena	Air travel contraindicated except in emergency Airline medical department must be consulted
(ii) Healed B. Post-operation	Distension of bowel under reduced pressure	Airline medical department must be notified Minimum of 10 days should have elapsed since operation Hyoscine to prevent airsickness if necessary Airline medical department must be consulted
C. Colostomy	Overactivity and poor control	Airline medical department must be consulted
RENAL DISEASES		
A. Calculus	Frequent attacks of colic	Normally no restriction Hyoscine to prevent airsickness
B. Other	Degree of impairment of function	Airline medical department should be consulted

(Continued on next page)

TABLE III.—Continued

Condition	Limiting Factors	Restrictions and Precautions
C.N.S. DISEASES		
A. Epilepsy	Frequent seizures	Special arrangements must be made if fits are uncontrolled
B. Mental disease	Behaviour must be normal under mild stress	Special arrangements, including sedation and an attendant normally required
C. Faecal or urinary incontinence		Cases will not normally be carried
INFECTIOUS DISEASES		
	Infectious phase	Will not be carried
METABOLIC DISEASES		
A. Diabetes		
(i) Stable and uncomplicated	Patient must understand his own case, and be able to administer his own insulin etc.	Time changes must be taken into account. Airline medical department should be notified and hyoscine given if necessary
(ii) Unstable or complicated		Special arrangements must be made
B. Liver diseases	Ascites or severe impairment of function. Possible rupture of abscesses	Airline medical department must be consulted
ELDERLY		
	Respiratory and cardiovascular function must be adequate. Bowel and bladder control must be normal	None, unless patient is not fully ambulant, when special arrangements should be made
PREGNANCY		
(i) First trimester		History of abortion is relative contraindication. Hyoscine to be given if necessary
(ii) 12–32 weeks		None if normal. Airline medical department to be notified
(iii) Beyond end of 32nd week		Oxygen to be available. Will not normally be carried on international flights

Queries

In the majority of the larger airlines there are specialist medical officers who have a great deal of experience in problems of the carriage of invalids by air, and there is a department which deals with the care and transport of such

passengers to which all such inquiries should be addressed. Application should be made to the airline concerned, when usually a questionnaire will be sent to be completed by the patient's private doctor. This will then be considered by the medical department, and a decision will be made on whether the patient is acceptable for air travel. If the answer is in the affirmative a briefing form is completed alerting the airline officials en route of the special services which will be required and setting in train the provision of such requirements from the port of departure through to the final destination. These arrangements may include the attendance of doctors, or the administration of drugs en route, the provision of certain items of medical equipment and oxygen sets, nursing facilities, or ambulance requirements.

Conclusion

Experience has shown that increasing numbers of seriously ill patients can be carried by air, and many of course benefit from the availability of this form of transport. The advantages offered by rapid transit, smooth flight at high altitudes, controlled atmospheric conditions within the cabin, coupled with the medical facilities available in flight such as emergency oxygen supplies, make air travel a most useful form of transportation for the seriously ill person who wishes to travel with a minimum of physical upset or discomfort.

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ANY QUESTIONS?

We publish below a selection of questions and answers of general interest.

"Arc Eye"

A.—What is the best topical application for "arc eye"?

A.—Local anaesthetic drops may be necessary for examining an eye after exposure to ultraviolet radiation, but their continued use is inadvisable. Adrenaline eye-drops are helpful in mild cases and cold compresses produce some alleviation of symptoms. Light should be excluded by bandaging the eyes.

Oral Contraceptives and Mitral Stenosis

Q.—Is there any evidence that oral contraceptives might increase fibrin deposit on the mitral valves in cases of mitral stenosis?

A.—It is very unlikely that thrombosis as such plays any part at all in the fibrotic narrowing of the mitral valve which leads

finally to mitral stenosis. Therefore oral contraceptives should not have any effect whatsoever on the rheumatic mitral valve.

Treatment of Barbiturate Poisoning

Q.—What are the main points in the treatment of barbiturate poisoning, and what are the indications for the administration of bemegride?

A.—Bemegride, though introduced as an antidote for acute barbiturate poisoning,¹ is an analeptic with no specific action against barbiturates. It and other analeptics have no place in the treatment of barbiturate poisoning.²

Since there is no antidote, the treatment consists in the maintenance of vital functions. Respiration has to be safeguarded by keeping the airway clear, and, if necessary, by

applying oxygen and artificial respiration. Shock will require vigorous management, the blood pressure being maintained with metaraminol. Hypothermia, hydration, and acid-base balance may all require active attention. Intensive nursing care is most important. These measures alone will be successful in 95% of cases. Gastric aspiration and lavage should be undertaken only within four hours of the ingestion of the tablets and if the lungs are protected by an adequate cough reflex or a cuffed endotracheal tube.³

Forced diuresis and peritoneal- and haemodialysis should be used only in exceptional circumstances—for example, when the condition deteriorates despite intensive measures to support vital functions. Treatment will not be complete unless the psychiatric aspects of the case are investigated and dealt with.

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