Occasional Survey

Aeromedical Evacuation of the Seriously Ill

H. F. OXER

British Medical Journal, 1975, 3, 692-694

Summary

Almost any patient may be carried by air, but air transport introduces some special problems owing to the effects of altitude, noise, turbulence, and the special environment. Because of these factors it is important to know when considering a patient's suitability for air transport the type of aircraft to be used, the flight profile—its duration and expected cabin altitudes—and the facilities available on board. It is essential to carry all equipment (as simple and as portable as possible), drugs, and diets that may be needed, and to be sure that all the skills and nursing help needed to deal with any possible problems are available.

Introduction

With the ever-increasing role of air travel, doctors are more often being asked to make decisions about a patient's fitness to travel by air. The type of patients who may be accepted for travel in an ordinary airline seat has been reviewed,^{1,2} but doctors may be approached for advice on transporting a patient by air who cannot travel in a normal passenger seat and who may need nursing or medical attention in flight. This paper outlines some points for consideration when presented with such a problem.

Almost any patient may be carried by air. The journey may be more comfortable than in an ambulance over second-class roads, and the reduced time spent in reaching medical help may be life-saving. There are, however, several special problems peculiar to air transport, which vary with the type of aircraft used, the length of the flight, and the patient's age, diagnosis, and clinical condition.

Aircraft

Aircraft likely to be used for aeromedical work may be considered in four categories: (a) those propelled by jets, whether long range, medium range, or small "executive" jets; (b) medium- and short-range propeller-driven aircraft, such as company aircraft and those used by internal airlines and feeder airlines; (c) light aircraft, usually privately owned, propeller-driven, and with few (usually four) seats; and (d) rotary-winged aircraft (helicopters).

JET AIRCRAFT

Most jets fly between 20 000 and 45 000 ft (6096 and 13 716 m) altitude, which is above most of the weather. Except during climb and descent flight may be expected to be relatively smooth, though the sudden short accelerations of "clear air turbulence" may be encountered and may be quite violent and troublesome. Noise levels are surprisingly high, and a stethoscope is rarely useful, even in the quietest of airliners.

Ambient atmospheric pressure falls with increase of altitude. The International Commission on Air Navigation Standard Atmosphere at mean sea level is 760 mm Hg (101.3 kPa) at 15°C; at 6000 ft (1829 m) this has fallen to 609.1 mm Hg (81.2 kPa) and 3.12°C, and at 32 000 ft (9754 m) values are 205.9 mm Hg (27.5 kPa) and -48.36°C. The partial pressure of oxygen will fall proportionately.

An acceptable environment within the aircraft must be created by heating and pressurizing the cabin atmosphere. Maximum cabin altitude attained in commercial aircraft is around 8000 ft (2438 m), which will achieve an oxyhaemoglobin saturation of 90% in a healthy person. This is acceptable in the healthy adult at rest, but the inspired oxygen partial pressure of about 13.3 kPa (100 mm Hg) may produce unacceptably low arterial oxygen tensions in patients with impaired oxygen uptake or transfer.

Relative humidity in pressurized aircraft is very low, and on long flights often falls below 10%. Humidification for patients with artificial airways is necessary.

PROPELLER-DRIVEN AIRCRAFT

Medium- and short-range propeller-driven aircraft fly at a lower altitude and may not be pressurized. They are more likely to fly through turbulent weather, and noise levels may be higher. Space and facilities may be limited, but journey times are shorter.

LIGHT AIRCRAFT

Light aircraft are of limited use in an aeromedical role. The noise level is high and space is limited for the patient and attendant. There is usually insufficient height for intravenous infusions, no space for equipment, and extremely limited access for treatment or resuscitation. Turbulence levels may be high, and if flying above about 2500 ft (762 m) the effects of lowered atmospheric pressure must be considered.

HELICOPTERS

Helicopters, whether designated for passenger transport or as multi-purpose aircraft, are usually very noisy, with a high vibration and turbulence level. Communication may be limited and is at times almost impossible except by signs. Access may be limited and facilities poor. The helicopter's main advantage is its ability to operate from small areas close to the point of departure and destination.

Preparation

When considering patients for air travel a careful history should be taken. As well as considering the features of the primary condition

Department of Anaesthesia, Princess Alexandra's Royal Air Force Hospital, Wroughton, Swindon, Wilts SN4 0QL

H. F. OXER, F.F.A., R.C.S., Wing Commander, Consultant Anaesthetist

the state of the cardiac and respiratory systems should be examined carefully in the light of the proposed flight profile.

Additional important factors may include a tendency to syncope, vertigo (possibly associated with middle ear disease), or motion sickness, sickle-cell trait, and a history of diabetes or epilepsy. Phobias, particularly flying phobias and claustrophobia, should be considered, as should any form of psychiatric illness or alcoholism.

In the light of this information on the patient the following factors should be considered: effects of altitude (hypoxia, dysbarism), noise, turbulence, space and access, relative humidity, power supplies for equipment, equipment portability and compatibility, facilities for nursing, refuelling stops, and drugs and oxygen.

EFFECTS OF ALTITUDE

Hypoxia

The partial pressure of oxygen will fall with increase in actual aircraft altitude or, if pressurized, with the increase in cabin altitude. Ambient pressure at 8000 ft (2438 m), which is the maximum cabin altitude to which one may be exposed, is 74.7 kPa (560 mm Hg), which gives an inspired oxygen tension of 15.3 kPa (115 mm Hg) and a normal alveolar tension of 8.7 kPa (65 mm Hg). Thus, any patient with impaired lung or cardiovascular performance, though able to cope adequately on the ground, may be severely affected at these levels. If the arterial oxygen tensions in patients at risk are known the need for added oxygen may be assessed before flight.

Dysbarism

Gases expand with falling ambient pressure in accordance with Boyle's law. At maximum cabin altitude there will be an expansion of gas of about 30% and a similar contraction during descent. Expansion of gas above the surface of fluid in a rigid intravenous infusion container will speed up the drip flow and slow it down during aircraft descent unless the air is vented by a long tube to cabin atmosphere. Soft plastic containers are easier to manage. Expansion of air in the drip chamber will lower the level of fluid during ascent; this will rise again during descent.

Air in the cuff of an endotracheal tube or tracheostomy tube will expand, causing increased pressure on the tracheal wall. During descent the contraction may cause a leak past the deflating cuff, which may not be noticed because of the high background noise. Large-volume, low-pressure, or "foam" cuffs may be used with advantage.

A patient with a pneumothorax should not be accepted for air transport unless the pneumothorax is small and well sealed or has an intrathoracic drain. Such pleural drains are easily managed with the aid of a Heimlich valve, its outlet connected to a plastic bag such as a urine bag. An underwater drain is less convenient on aircraft.

Expansion of air within the abdomen may tend to splint the diaphragm and cause respiratory embarrassment. Air within the gut may give rise to colicky pain, abdominal distension, and, in the unconscious patient, may cause evacuation of the lower bowel.

Cysts containing air will enlarge and may rupture. In particular, a patient who has air in the skull—for example, after an air encephalogram—should not be accepted for air travel until the air has reabsorbed unless the cabin altitude of the aircraft can be kept at or near sea level.

Air splints may become tense enough to obstruct the circulation to a limb even at altitudes of 1500–2000 ft (457–610 m) unless excess pressure is relieved. Vacuum splints will tend to soften with height, but are easily adjusted by evacuating a little more air during climb.

A patient with air inside the globe of the eye is at risk, and an expert ophthalmic opinion should be sought on the effects of gas expansion before emplaning such a patient.

Flying at altitude is inadvisable shortly after recent scuba-diving, as the further fall in ambient pressure may bring on symptoms of decompression sickness. The British Sub-Aqua Club recommend an interval of not less than 24 hours after a significant dive before flying.

NOISE

Noise levels in modern jet aircraft are diminishing, but they are still high enough to make a stethoscope of little value. It is also not possible to hear, for example, air leaks around a tracheostomy tube or the familiar sounds of a ventilator, which makes careful monitoring of

ventilator performance, by repeated observation and measurement of tidal volumes and pressures, mandatory. Noise levels in smaller aircraft may be much higher, and in most helicopters are such as to make communication very difficult. Auscultation is impossible, and ear defenders for both patient and attendants may be necessary. The high noise level may cause considerable distress, especially to young patients.

Because of the inability to use a stethoscope blood pressure is usually monitored by palpation to obtain a systolic pressure reading. A mercury sphygmomanometer is absolutely forbidden because if split the mercury may endanger the aircraft. An aneroid sphygmomanometer is satisfactory.

TURBULENCE

A means of restraint for the patient and the litter is essential. A patient harness, such as that used by the Royal Air Force, provides effective and comfortable restraint for the patient during turbulent flight or emergency. Effective restraint for the litter may not be easy; on some civil flights the stretcher may be placed on the back of folded-down seats, which is less than ideal but may be unavoidable. Patients unrestrained on the stretcher may slide about during take-off, during the steep climb-out demanded by noise-reducing operating techniques, or during braking on the landing run. Severe turbulence during flight demands good patient restraint.

Turbulence and vibration increase the incidence of motion sickness, and an attendant bending over a patient subjected to accelerations in an unusual plane may also have an increased liability to sickness.

Skull or limb traction on an aircraft should be either fixed or, preferably, by use of Tensator springs, which apply a constant traction irrespective of the extension of the spring. Any form of weight traction will vary considerably during flight, owing to the effects of varying *g* forces, and should be avoided.

SPACE AND ACCESS

In large wide-bodied jets there may be adequate space and access to the patient, but if a patient's stretcher is placed across folded-down seats access may be much more limited. In light aircraft the patient may be on a litter on the floor, with the feet through into the luggage compartment, and the attendant kneeling on the floor. Such aircraft are not high enough to allow a satisfactory intravenous infusion, and space for any form of treatment or resuscitation is very limited. There may be little room for any specialized equipment, and no room to use it. In a helicopter there may be more space, but high vibration and turbulence levels make any treatment difficult.

If possible a patient should be positioned so that an attendant can be seated, strapped in, near enough to the head of the patient to attend to essential needs such as the airway during take-off and landing.

RELATIVE HUMIDITY

An aircraft cabin is pressurized by bleeding air from the engine. This hot air is cooled but becomes very dry, and the necessary equipment to adequately rehumidify the air is too bulky and heavy to be carried in an aircraft. Levels of relative humidity of less than 10% are common on a long flight. This is merely uncomfortable for the conscious patient, and can be relieved by oral fluid intake. In the patient with an artificial airway moisture must at least be conserved—for example, by a condenser-humidifier. It is preferable to supply warmed humidified air to prevent drying and crusting of secretions and possibly patchy atelectasis of the lungs.

POWER SUPPLIES FOR EQUIPMENT

An electrical supply is rarely available to an aeromedical team on civil aircraft (though all Royal Air Force aircraft and helicopters capable of carrying sick patients have 28-V D.C. supply points for this purpose). Thus, all equipment must be operated by either batteries or compressed gas. Batteries containing liquid electrolyte are most unwelcome on aircraft, due to the risk of aircraft damage by spilt acid. If carried they are subject to special safety packing precautions. It should be remembered that over a long international flight several such batteries may be needed to power an incubator, ventilator, or humidifier.

The amount of compressed gas—for example, oxygen—needed to power a ventilator over a long flight may be considerable, and cylinders are bulky, heavy, and difficult to secure. Oxygen cylinders are considered dangerous cargo. The aircraft emergency oxygen supply is for practical purposes not accessible for use, though small portable cylinders are carried by airlines for emergency use.

COMPATIBILITY AND PORTABILITY

It is essential that all electrical and electronic equipment is carefully checked for its avionic compatibility before being used on an aircraft. Unsuitable equipment may emit radiation frequencies that interfere with the navigation and signalling equipment of the aircraft. This may preclude use of equipment from intensive care units, however portable.

FACILITIES

Even on a large aircraft the facilities for disposing of items such as bedpans are very limited. Special diets can usually be provided if ordered in advance. The proximity of other passengers makes the problems of dealing with incontinence in an unconscious patient no easier, and all paralysed or unconscious patients should have bowel emptying performed as thoroughly as possible before emplaning on a long flight.

Lighting levels may be poor, especially at night, when main cabin lighting is turned off. The usual overhead reading lights may not be adequate. Only basic first-aid facilities are carried on civil aircraft, and all medical and nursing requirements must be taken. It is essential to oversupply, as opportunities for restocking en route may not occur.

Cabin staff are most willing, but are fully occupied with their normal duties, and can rarely help with patient care. Medical advice may be obtainable through the aircraft captain by radio in an emergency, though reception conditions may not always be helpful.

REFUELLING STOPS

It will not always be practicable to remove a patient from the aircraft during refuelling stops. During this period, in hot climates, the conditions inside an aircraft may become very hot and humid. Because of the distance of most large airfields from city centres it may not be possible to obtain medical or nursing help—airport medical staff may be more oriented towards industrial health and immigration problems than treatment of the seriously ill.

DRUGS AND OXYGEN

It is essential to carry any drugs that may be needed in sufficient supplies to cover both the journey and intermediate stops and any unforeseen delays. It is advisable to keep one's requirements simple, and administration is best carried out in accordance with "Zulu" time (Greenwich Mean Time) rather than the varying local times. To avoid problems with the authorities it is advisable not to take narcotic drugs and to use, for example, pentazocine injections as a strong analgesic. Drugs that are sensitive to heat when stored should be avoided.

Sufficient oxygen should be carried to cover one's maximum estimated requirements, bearing in mind that as well as the flight time there may be a considerable period of time on the ground at the beginning and end of the flight. If necessary arrangements must be made for resupply at intervening stops along the route.

I am grateful to Air Commodore E. J. McGuire for his help and advice, and to Air Marshal Sir Geoffrey Dhenin, Director-General of Medical Services, Royal Air Force, for permission to make this report. Crown copyright is acknowledged.

References

- 1 McGuire, E. J., *Health*, 1974, 2, 28.
- 2 Richards, P. R., *Practitioner*, 1973, 210, 232.

Letter from . . . Chicago

Pyramids and Primary Care

GEORGE DUNEA

British Medical Journal, 1975, 3, 694-696

During his extensive travels through the lands of the ancient world Herodotus observed that among the physicians of the venerable kingdom of Egypt "some specialized in diseases of the eyes, teeth, head or belly, while others dealt with the kind of illness that could not be exactly localized" (*Herod*, 2, 84). But while these ancient Egyptian generalists may well have been consultant physicians, at the top of the medical pyramid, who made the correct diagnosis when the head and belly specialists disagreed on a case of abdominal migraine, the modern American general practitioner has clearly become the low man on the totem pole, and, in fact, he is in danger of extinction. Within 40 years the number of general practitioners in the

U.S. has dropped from 120 000 to 50 000. Of all doctors in the country fewer than one-half are primary physicians and fewer than one-fifth are general practitioners. Yet the need for primary care remains as great as it was 15 years ago, when Dr. Henry Miller wrote that "the most searching questions which face medicine at the present time concern family practice."

Through its legislative agents, the general public has of late expressed displeasure at this peculiar deficiency of American medicine, and even among the ivory towers and orange groves of academia echoes of discontent and a massive decline in grant moneys have at last prompted concern over what to many has long been one of the more remote frontiers of medicine. Last year Dr. Francis Moore, Professor of Surgery at Harvard, declared that "he did not waste any tears over whether the G.P. is here to stay or not," but conceded that he "wasted a lot of worry whether our access modes were in the situation they should be." In truth, medical care is at times inaccessible, often discontinuous and impersonal, and usually expensive. Critics of the system have described the overall situation as an unmitigated disaster.

Cook County Hospital, Chicago, Illinois, U.S.A.
GEORGE DUNEA, M.B., M.R.C.P., Consultant Physician