Chapter 19

WORLDWIDE AEROMEDICAL EVACUATION

OPERATIONAL CONCEPTS

Department of Defense policy requires the use of air transportation for the evacuation of the sick and wounded, unless medically contraindicated, when appropriate aircraft can be made available. The Department of the Air Force implements this policy by establishing and operating aeromedical evacuation systems for peacetime and limited war requirements. By integrating Air Force Reserve and Air National Guard units, the systems can be quickly expanded to meet full wartime requirements.

At the present time, the Air Force operates aeromedical evacuation systems to meet the following requirements: a. Between medical facilities within the Continental United States (CONUS); b. within oversea areas where US Armed Forces are stationed; and c. from oversea areas to the CONUS. Thus, all US Forces, wherever located, are provided with aeromedical evacuation support.

Several aeromedical evacuation systems are in operation at this time and are identified according to geographical/operational factors as *domestic, intertheater,* and *intratheater.* A domestic system operates within the CONUS; two intratheater systems operate within oversea areas. A tactical system is capable of being put into operation by units of the Tactical Air Command. Sometimes, the terminology "tactical aeromedical evacuation system" is used; it refers to the intratheater systems. Similarly, the term "strategic" refers to the evacuation of patients between oversea areas.

The intertheater systems are the least complex. The flow of patients is in one direction from a limited number of oversea aerial ports to one of several in the United States. By contrast, the domestic and intratheater systems operate into large numbers of airfields, perform many special missions, and provide a 24-hour, on-call emergency service. All systems perform essentially the same functions and require the coordinated efforts of similar activities.

Several kinds of air transport and medical service activities combine or coordinate their efforts to make an aeromedical evacuation system operationally effective. A listing would include at least the following: (1) Air transport activities, such as transport and troop carrier units, airlift command posts, and air and ground communications; (2) air terminal and aerial port activities, such as air evacuation control centers, flight line services, food services, and ground transportation; and (3) medical activities, such as casualty staging, medical regulating agencies, originating, en route and destination hospitals, and aeromedical evacuation units. The actions of all these elements must be closely coordinated. Poor coordination will result in loss of airlift and a breakdown in the orderly flow and timely evacuation of patients to medical treatment facilities.

Continental US Operations—The Domestic System

The mission in the CONUS is to operate a domestic aeromedical evacuation system for the transfer of patients from aerial ports of debarkation to destination hospitals, and between medical facilities within the United States. The operation of this system presently involves aeromedical airlift squadrons, detachments, casualty staging units, aerial ports, aeromedical evacuation control centers, about 500 airfields, and approximately 200 military and 185 Veterans' Administration and Public Health Service hospitals.

The peacetime mission is accomplished with pressurized aircraft that are used exclusively for transporting patients. The domestic system operates a. A scheduled coast-to-coast trunkline service to keep aerial ports cleared, to provide a connection with feeder flights at terminals along the route, and to transfer patients between terminals on the trunkline; b. feeder flights to transfer patients between trunkline terminals and hospitals not on the trunkline; c. a scheduled service to Alaska, Northeast Caribbean, and adjacent Atlantic areas; and d. semischeduled and special flights to transfer patients between medical facilities that are not serviced by the trunkline. This MAC system provides a network of daily flights, which could be quickly augmented with Air National Guard and Air Force Reserve units for wartime operations (see figure 19-1).

Overseas to CONUS Operations—
The Intertheater Systems

The mission of an intertheater system is to provide aeromedical evacuation from oversea areas to the CONUS. Two intertheater systems may be identified with the following geographical areas of responsibility: a. From the Far East-Pacific area and b. from the European area. These systems are an integral part of the MAC global air transport system which provides logistical air support for all US Forces outside the CONUS.

The delivery of cargo, personnel, and mail to these oversea locations creates a large return airlift capability, part of which is used for the evacuation of patients. The utilization of return airlift as the sole resource for aeromedical evacuation from oversea areas is one of the operational distinctions of intertheater systems which would also be employed by the other systems in the time of war.

The efficient operation of intertheater systems requires (1) multiengined, pressurized transport aircraft equipped with removable airline seats and litter support devices for quick conversion from passenger/cargo to aeromedical configuration; (2) casualty staging facilities at aerial ports of embarkation and debarkation; (3) sufficient numbers of aeromedical flight crews and equipment located at aerial ports and intermediate terminals; and (4) appropriately located aeromedical evacuation control and liaison centers staffed by medical service personnel who are familiar with aeromedical evacuation procedures and air transport operations.

Modern fleets of pressurized, dual-purpose jet aircraft are used for peacetime intertheater operations, consisting of C-141 aircraft, at this time. For critical wartime situations, the C-130 turboprop cargo transports would be available also.

During peacetime, the heavy cargo/passenger transport aircraft is capable of carrying a mixed litter/ambulatory load of approximately 70 patients. The basic medical crew consists of two flight nurses and three aeromedical evacuation technicians. In wartime, the number of patients carried would be greater, probably approximating the maximum capacities of the various aircraft. Aeromedical crews would be augmented, when required; however, during the initial period of a national emergency, the nonavailability of medical crews could result in some flights having less than a basic crew aboard.

Intratheater Systems

The mission of an intratheater system is to provide aeromedical evacuation for all US Forces within a theater of operations or oversea area. The Air Force presently operates two intratheater systems. One encompasses the European-Mediterranean-Near East area (figure 19-2); the other, the Far East-Pacific-Southeast Asia area (figure 19-3). For the peacetime mission, these systems operate in a similar manner and provide services comparable to the domestic system. Under wartime conditions, support of combat operations is the primary task, requiring the use of troop carrier and assault aircraft, involving a change in operational procedures from the single mission to the dual mission or "return airlift" concept.

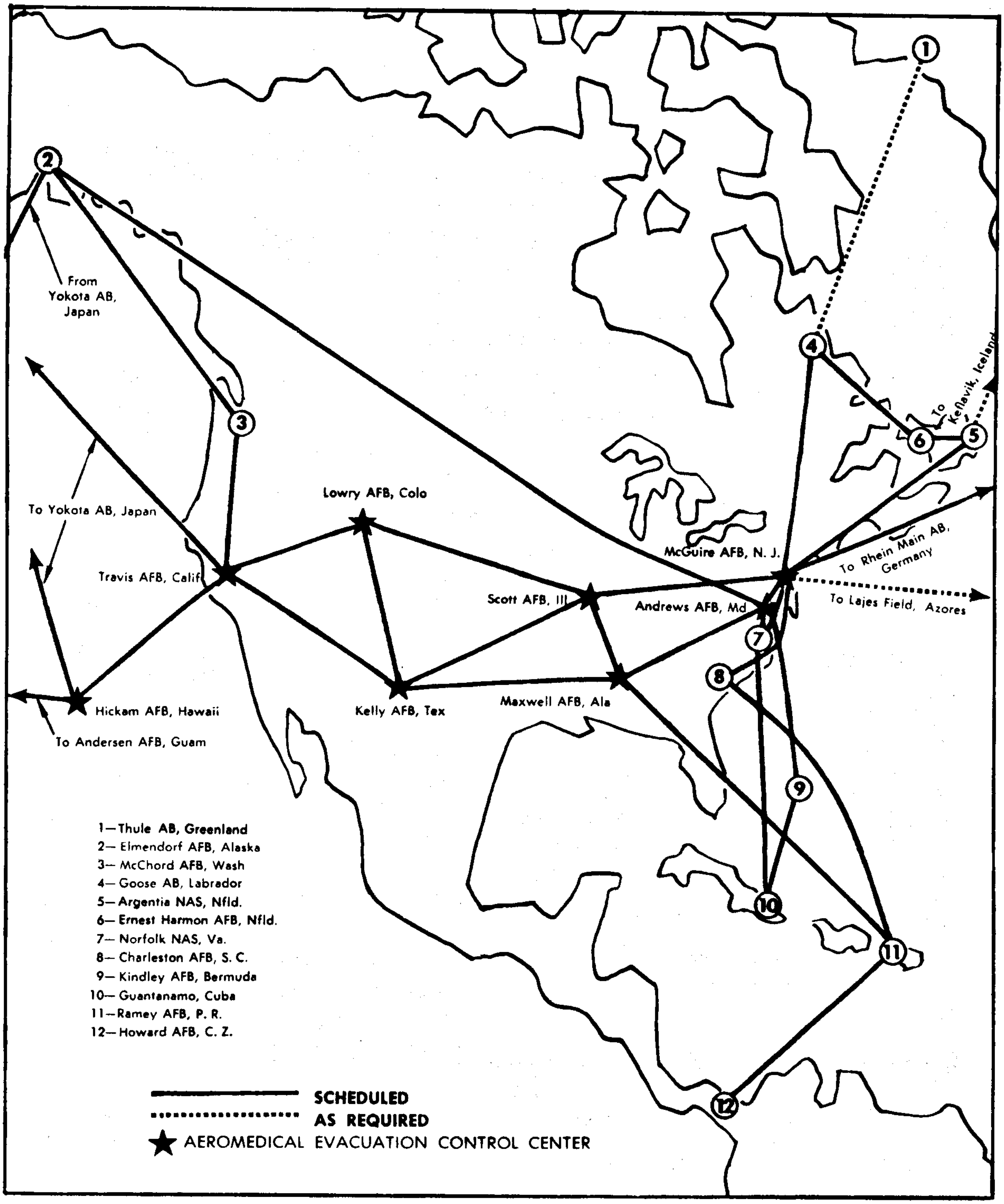

Figure 19–1. Domestic System.

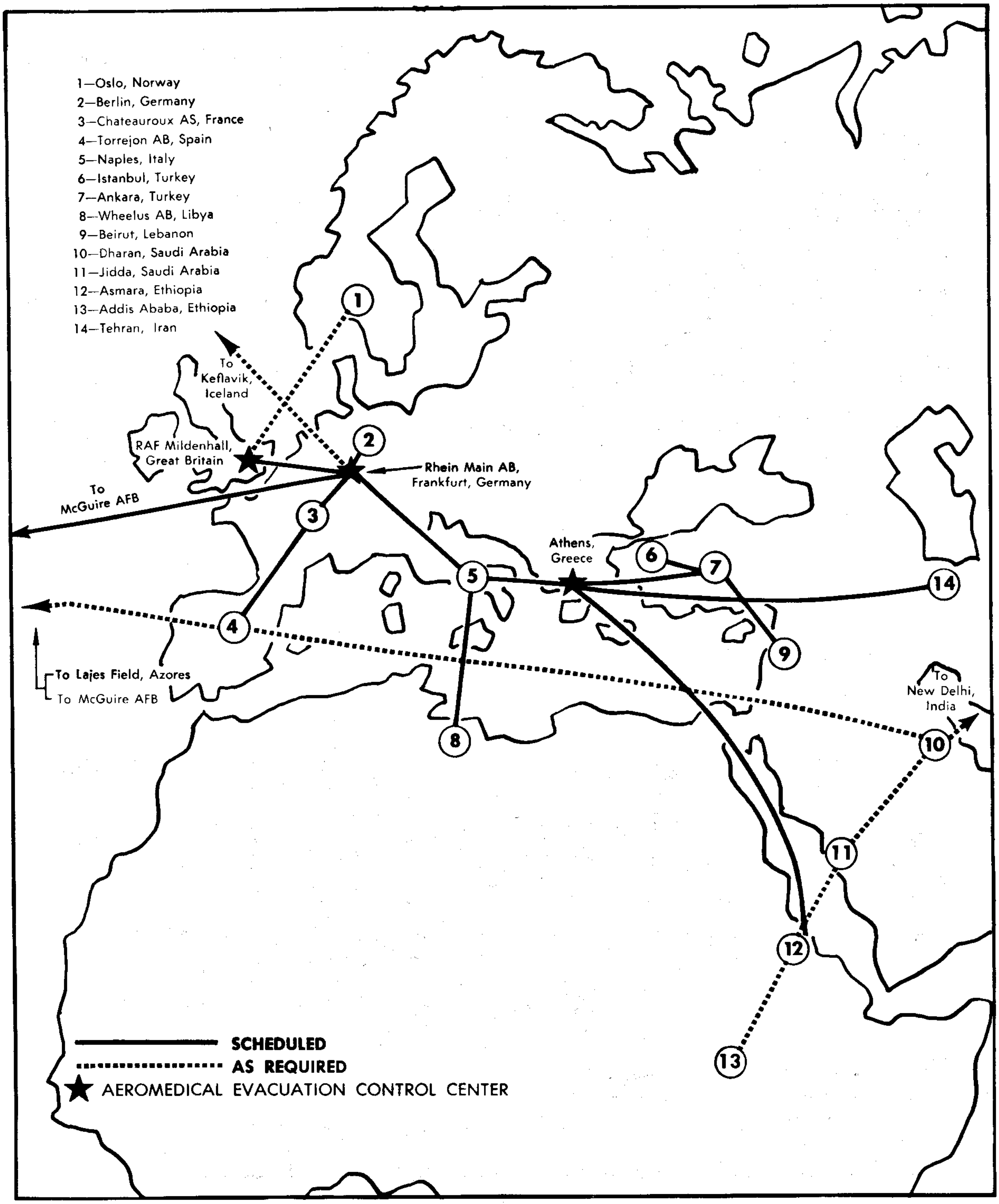

Figure 19–2. European-Mediterranean-Near East Area.

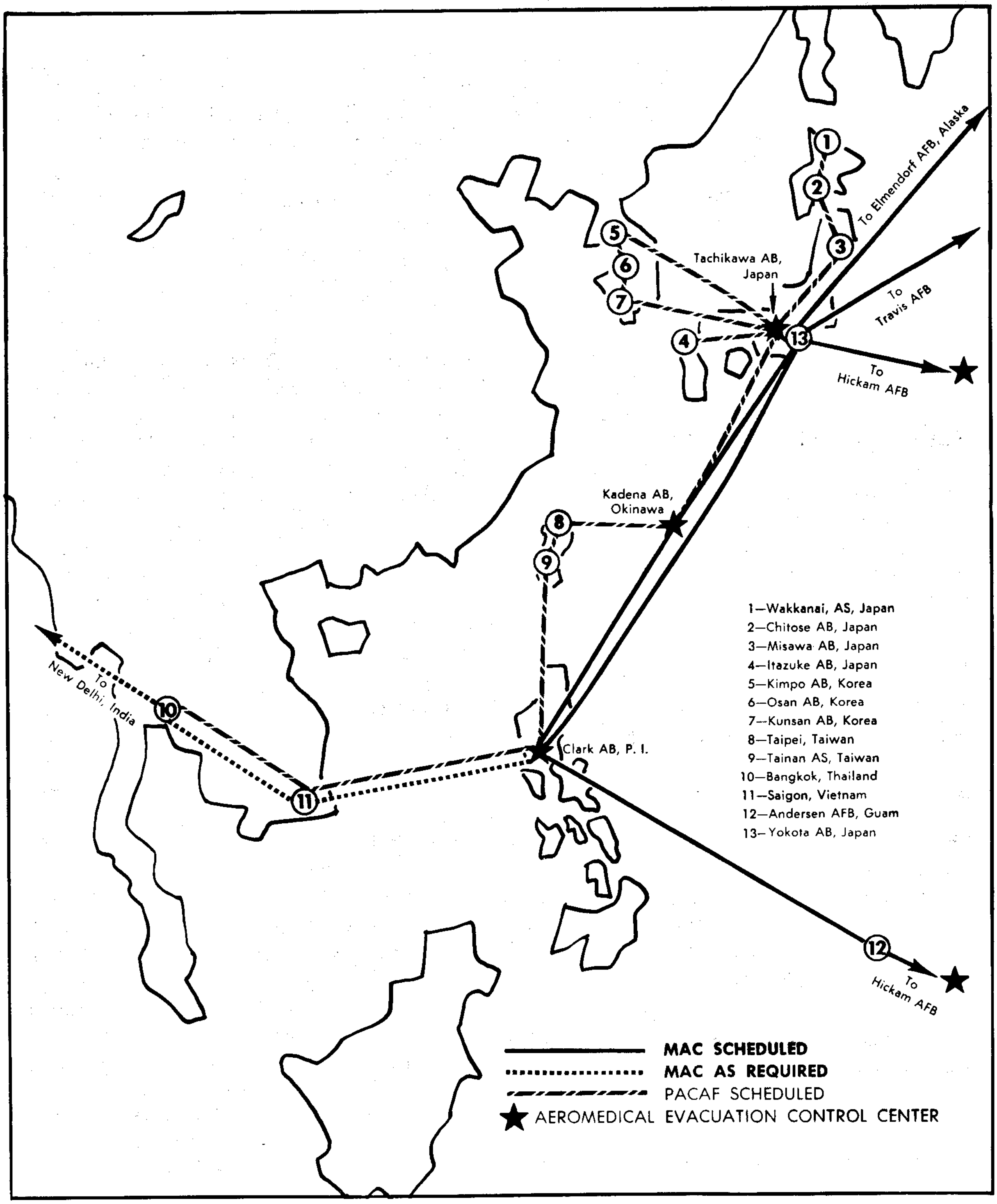

Figure 19–3. Far East-Pacific-Southeast Asia Area.

The Air Force recognizes that the peacetime mission of intratheater systems includes the evacuation of women and children, and involves medical and surgical conditions which would not normally be encountered in wartime. Pressurized aircraft with comfortable accommodations are used when possible, and both outbound and inbound flights are normally flown for the aeromedical mission, using the outbound flight to return recovered patients to their home stations. Passengers normally use seats not required for patients.

Intratheater aeromedical evacuation, being a collateral function of logistical air support operations, has the entire theater airlift resources at its disposal. This airlift, consisting primarily of cargo/troop carrier aircraft, will form the backbone of wartime evacuation resources. Therefore, it is important that troop carrier and aeromedical evacuation elements train and exercise in dual-mission operations through periodic command exercises and operational readiness tests, and also participate in joint field exercises when possible.

Intratheater systems are organized, staffed, equipped and oriented to the primary mission—combat support. The realities of peacetime deployment of forces are recognized, however, and every effort is made to maintain intratheater systems which provide a service appropriate to peacetime conditions while maintaining responsiveness to the wartime mission.

All of the normal requirements for casualty staging, coordination, control and liaison, aeromedical flight crews, special equipment, and standard operating procedures also apply to intratheater operations. Additional requirements include the ability to: a. Support air-landed airborne operations, b. rapidly convert to litter configuration and load all types of assault, cargo, and troop carrier aircraft, and c. integrate with the wartime logistical air support system without any significant changes in command, organization, deployment or operating procedures.

Aeromedical Evacuation Coordination, Control, and Communication

The advantages of aeromedical evacuation, when compared with other modes of transportation, may be measured in terms of lives, time, and resources saved. A constant effort is made, therefore, to reduce the time between the entry of patients into the evacuation system and their delivery at destination hospitals. Two related actions—efficient use of aircraft and short turn-around or ground time—contribute directly to this objective. The degree of success in achieving this objective is largely dependent upon the effectiveness of coordination and control.

Coordination, which is effected by all elements of the system and by activities using the system, keeps all appropriate agencies and activities informed of evacuation requirements, estimated aircraft arrival times, changes in requirements and estimated times of arrival (ETAs), and any other details which should be made known to other activities.

Aeromedical airlift control and patient traffic control are performed by elements of the evacuation system that are located at aerial ports and air terminals. Aeromedical airlift control assures that the scheduling and routing of aircraft will satisfy the evacuation requirements within the area of operations. Patient traffic control insures that the number of patients by type, delivered to specific airfields within the area of responsibility, does not exceed the space available at the specific points of pickup. These control functions are performed by aeromedical evacuation units at key terminals and aerial ports.

Effective coordination and control require the use of all available means of communication. All aeromedical evacuation elements must have authority to use whichever means are appropriate to the situation. The more widespread the area of responsibility, the greater are the problems of communication and the greater the importance of timely communication.

The medical and logistical advantages of aeromedical evacuation are quickly lost without effective day-to-day coordination and control, as were practiced in certain instances during World War II, the Korean War, and the Vietnam Conflict.

Casualty Staging

Present operations are based on the concept that aeromedical evacuation is a collateral function of airlift operations, and that the coordination and control procedures for the employment of airlift are essentially the same for both. The most effective coordination and control are achieved when casualty staging activities are employed at key points in the system.

Casualty staging, the counterpart of aerial port squadrons which control and supervise the delivery and loading of troops and cargo, provides similar services for patients at aerial ports and terminals. Casualty staging increases aircraft utilization and decreases aircraft turn-around time. The in-transit time of patients is shortened, airlift is not lost, nor are aircraft departures delayed because of late arrival of patients. Furthermore, patients are not held in ambulances on the flight line because of late arrival of aircraft, and advantage can also be taken of opportune airlift. In effect, all of the details of coordination, communication, and patient handling and care at the airfield are simplified and more efficiently managed in the time available through the use of casualty staging.

A listing of casualty staging functions includes coordinating aeromedical evacuation matters within the area of responsibility and regulating the flow of patients. Included among the required additional duties are providing or arranging for shelter; medical care; feeding; medical screening; administrative processing; ground transportation and loading of patients; and otherwise providing for the welfare and expediting the transfer of patients entering, en route, or leaving the aeromedical evacuation system.

AEROMEDICAL AIRCRAFT

The purpose of this section is to discuss the various aircraft used in aeromedical evacuation. Table 19-1 compares the various types of aircraft and is an index for the narrative descriptions of the aircraft that follow it.

The figures given in this chart may vary in different models of the same type aircraft. The approximate cruising speeds will vary with load and distance to be flown. The ambulatory and litter loads will vary with different models and are governed by the regulations of the operating organization. Equipment also varies with individual aircraft of the same type.

C-131 Consolidated-Vultee "Convair"

The C-131, "The Samaritan" (figure 19-4), is a twin-engine aircraft especially designed for aeromedical evacuation. Its pressurized cabin can accommodate a maximum of 27 litter patients or 32 ambulatory patients. A combined load uses 12 litters along the left side and 17 rearward-facing airline seats on the right side.

This aircraft is equipped with standard litter-securing devices. The litters can be placed in three tiers of four each on both sides, with one tier of three on the rear left side opposite the latrines. Normally, however, this last tier space is used for baggage and equipment stowage.

Litter patients are loaded through the cargo door in the left rear section. These patients are placed in the tiers, feet forward. Ambulatory patients can be loaded by way of the built-in steps in the right forward section of the aircraft.

Special features include special lighting facilities, a well-equipped galley, individual fresh-air blowers, loudspeaker system, permanently partitioned latrines, and adequate sound attenuation.

The C-131 is the primary peacetime aeromedical aircraft. It is one of several aircraft used in the MAC domestic and intratheater systems.

C-118 Douglas "Liftmaster"

The C-118 (figure 19-5) is a four-engine aircraft with a pressurized cabin. It has a capacity of 60 litter patients or 61 ambulatory patients. It is equipped with standard litter support straps and wall brackets. There are individual oxygen supply controls and 24-volt electric outlets.

Patients are loaded through the rear main cargo doors. For ground operation in aeromedical work, external air-conditioning and heating are required. This aircraft is automatically pressurized and air-conditioned in flight.

C-141 Lockheed "Starlifter"

In 1965, the Lockheed C-141 "Starlifter" succeeded the Boeing C-135 as the major MAC long-range jet transport. The C-141 (figures 19-6 and 19-7) is a high speed, long-range, high swept-back wing monoplane, powered by four turbofan engines. Being

Type	No. of Engines	Cruise	Maximum Ambulatory Patients	Maximum Litter Patients	Name	Civilian Designation
Military Airlift Command						
Prop						
C-131	2	240	32	27	Samaritan	Convair 240
C-118	4	230	61	60	Liftmaster	DC-6
Jet						
C-141	4	425	95	72	Starlifter	L-300
Air National Guard						
Prop						
C-97	4	235	73	54	Stratocruiser	
C-121	4	240	71	44	Super Constellation	
Other Aircraft with Aeromedical Capability						
C-47	2	145	27	24	Skytrain	DC-3
C-54	4	171	49	36	Skymaster	DC-4
C-7	2	134	30	20	Caribou	
Turboprop						
C-130E	4	280	85	70	Hercules	
Helicopter						
HH-43	1	80	8	6		
H-19	1	90	10	6		
Aeromedical Aircraft to Replace C-131 and C-118						
Jet						
C-9A	2	480	46	40		DC-9

Figures for patient loads with full aeromedical crews are for maximum ambulatory and litter patient loads.

Figure for conversion of seats to litters (seat equivalents):
a. 2 seat side aircraft = 3 or 4 litters replaces 6 seats.
b. 3 seat side aircraft = 3 or 4 litters replaces 9 seats.

TABLE 19–1. AIRCRAFT USED IN AEROMEDICAL EVACUATION.

145 feet long with a wing span of 160 feet, its spacious cargo compartment can be equipped to carry over 150 troops and up to 80 litters in rows of three and four tiers each. In this latter configuration, there is space for up to sixteen attendants. Various combinations of litters and seats for ambulatory patients are possible. The usual configuration is 27 litters and 42 seats. Average cruising speed is 425 knots at an average cruising altitude of 33,000 feet. With a litter load of 80, the nonstop range is 5,000 nautical miles. Time taken to convert from cargo to patient use is less than two hours.

It must be emphasized that the C–141 is a multimission aircraft, capable of transporting troops or over 50,000 lbs of cargo outbound and returning on aeromedical evacuation missions.

Crew and patients have separate oxygen systems. The latter system can supply 80 litter patients with a continuous flow of oxygen for nine hours at 25,000 feet cabin altitude. The oxygen flow can be manually initiated or occurs automatically at cabin altitudes of 12,500 feet. Some of the oxygen distribution lines are permanently installed and others can be attached with the litter stanchions. Two regulator panels are available for the therapeutic oxygen system. Masks are the plastic throw-away type with quick connect-disconnect fittings.

Two identical and parallel air-conditioning systems control the environment of the aircraft, supplying conditioned air. Temperature control is achieved through ceiling and floor heating. Cabin temperatures are comfortable. In-flight relative humidity varies from 3% to 25%, a distinctively suboptimal level and one which is given special consideration when tracheostomized patients are carried. Interior noise levels, though high by airline criteria, conform to military standards.

The aircraft is designed to operate with an 8.2 psi normal cabin pressure differential, with 8.6 the maximum. This allows the pressurization system to maintain sea level cabin pressure until the aircraft reaches 21,000 feet. At 33,000 feet, the usual cruising alti-

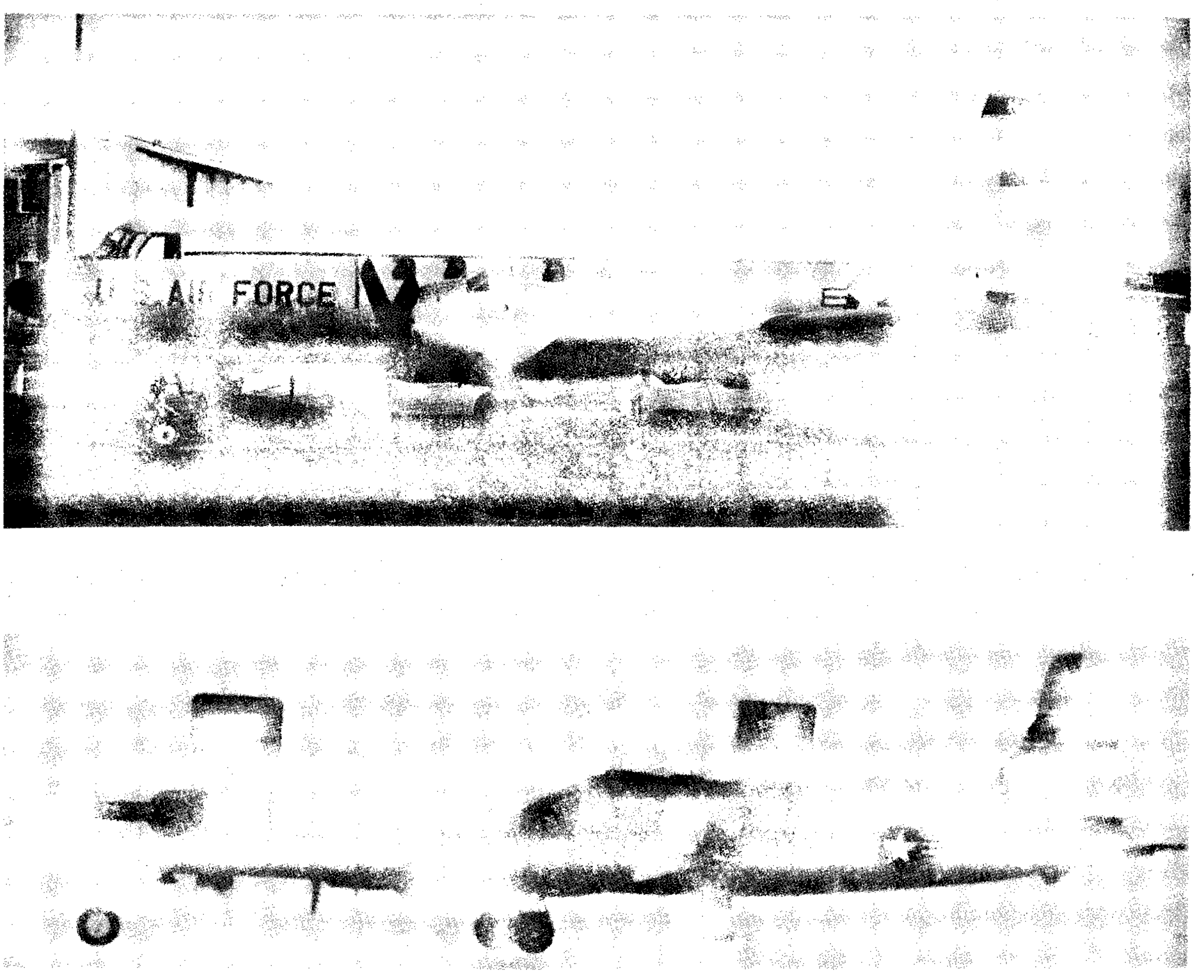

Figure 19–5. C–118 Douglas "Liftmaster."

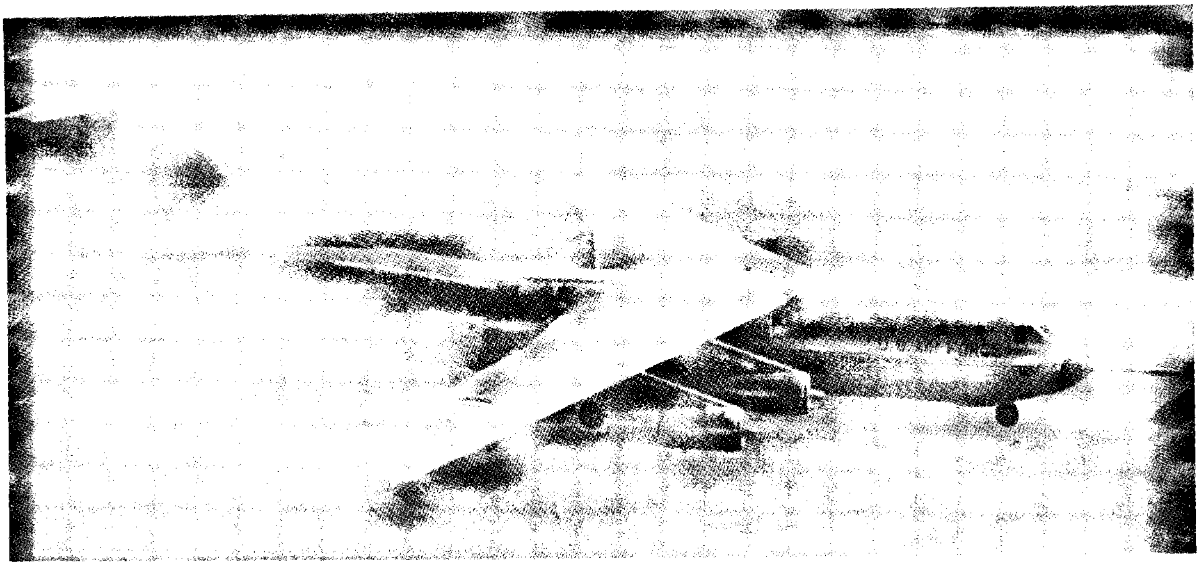

Figure 19-6. C-141 Lockheed "Starlifter."

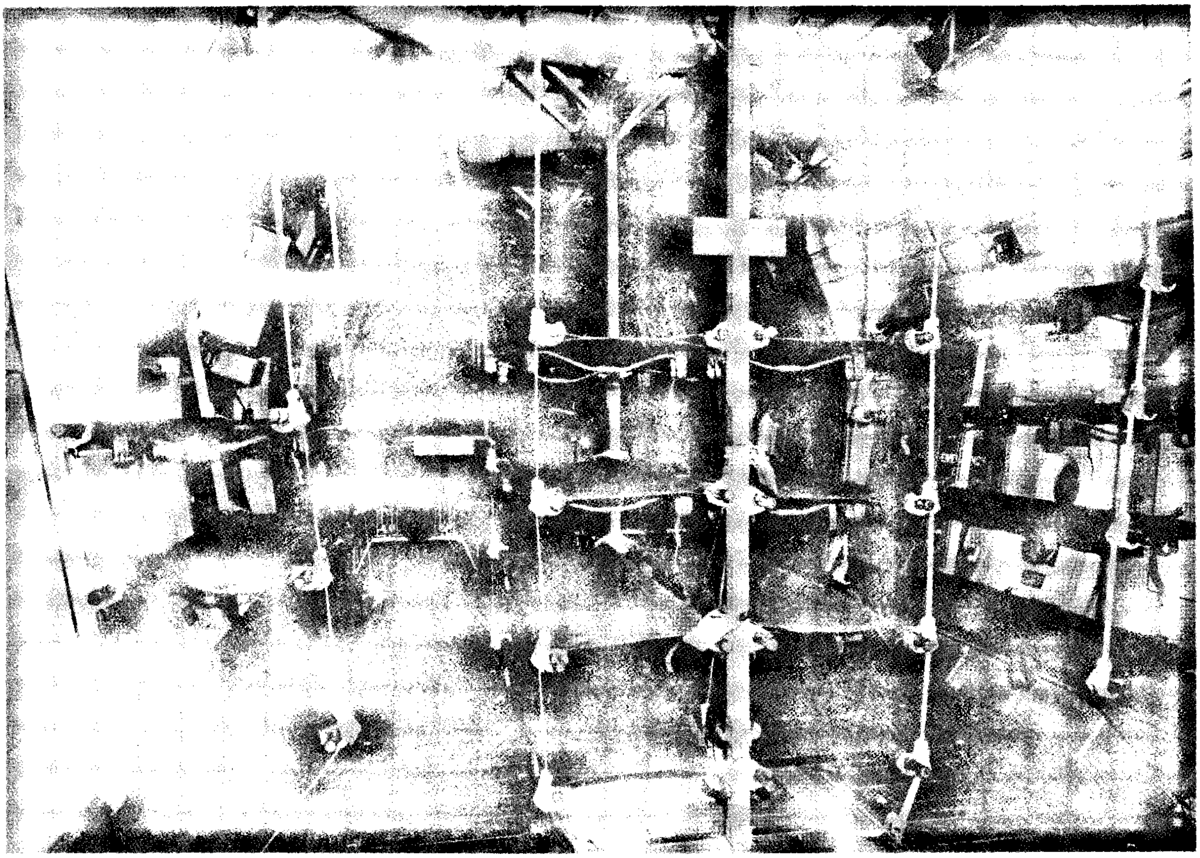

Figure 19-7. Interior View of C-141.

tude, a cabin altitude of 5,500 or less, is maintained. If required, sea level altitude may be achieved even at a flight level of 31,000 feet. At a level of 40,000 feet, the cabin altitude of 8,000 feet or less is possible. No instance of loss of cabin pressurization in an aeromedical evacuation flight has been reported in the C–141, and only one instance is known in its C–135 predecessor. The rate of cabin pressure change can be controlled for both ascent and descent.

A palletized comfort station is located at the forward end of the cargo compartment. The unit contains two flush-type latrines, wash basins, and well-equipped galley facilities. The necessary electrical and waste removal provisions for the comfort pallet are permanently installed.

Even the baggage storage is palletized. Five to six 20-man life rafts are carried and each patient has available an individual specially designed life vest.

C–97 "Stratocruiser"

The C–97 "Stratocruiser" (figure 19–8) is a midwing, heavy transport aircraft, powered by four radial piston engines. When seen head-on, the double-decked fuselage resembles a figure 8. Integral ramps have been incorporated for easy loading of patients. Standard webb strapping and wall brackets are used to secure litters. A maximum of 73 ambulatory or 54 litter patients can be accommodated.

C–97s are being used in the Air National Guard System.

C–47 Douglas "Skytrain"

The C–47 "Skytrain" (figure 19–10) is a piston-powered, twin-engine, nonpressurized aircraft. It has a litter capacity of 24 or a seating capacity of 27. There are six tiers with four litters in each tier. Standard litter support straps and wall brackets are used to secure the litters. Bucket-type seats or Evans canvas seats are used for ambulatory patients.

The C–47 is a low-door aircraft; therefore, no loading device is required in the onloading or offloading of patients.

The position of the litter patients in this aircraft is head forward, due to the plane's tail-low position on the ground.

The C–47 is not used for MAC aeromedical evacuation.

C–121 Lockheed "Constellation"

The C–121 Super "Connie" (figure 19–9) is a single-deck, four-engine (piston) aircraft with a pressurized cabin. This aircraft can carry 71 ambulatory or 44 litter patients. Standard webb strapping and wall brackets are used to secure the litters.

Ramps or mechanical loading devices are required when loading litter patients.

C–121s are being used in the Air National Guard System.

C–54 Douglas "Skymaster"

The C–54 "Skymaster" (figure 19–11) has four piston engines and a single deck, and is nonpressurized. The number of litter spaces ranges from 20 to 36. The maximum litter capacity is 32 in eight tiers of four litters each, plus eleven passenger seats. It has individual oxygen supply controls, built-in ventilation, and solar-reflecting paint. All C–54's are high-door aircraft requiring a special ramp or loading device for loading. The position of the litter patients in this aircraft is feet forward. The C–54 is not used in the MAC aeromedical system.

C–7 Caribou

Formerly a US Army theater cargo aircraft designated CV–2B, aircraft is used in theater of operations as a cargo/utility/evacuation aircraft.

The Caribou is a fixed-wing aircraft having a range of more than 1,100 nautical miles at a cruising speed of 134 knots. It has a crew of two and a maximum passenger capacity of 30. It can be used to carry up to 20 litter patients.

The Caribou is a rear-loading aircraft primarily designed for moderately heavy combat cargo support (see figures 19–12 and 19–13).

C–130E Lockheed "Hercules"

The Lockheed C–130E "Hercules" (figure 19–14) is a long-range transport plane with a pressurized cabin. It is capable of accommodating 85 ambulatory patients or 70 litter patients with attendants. The litters are carried aboard the airplane through the cargo-loading ramp door and are installed in four lengthwise rows in the cargo compartment. Stowage provisions for the litter-support stanchions are provided in the cargo compartment forward bulkhead.

The C–130E can land and take-off on short runways and can be used on landing strips

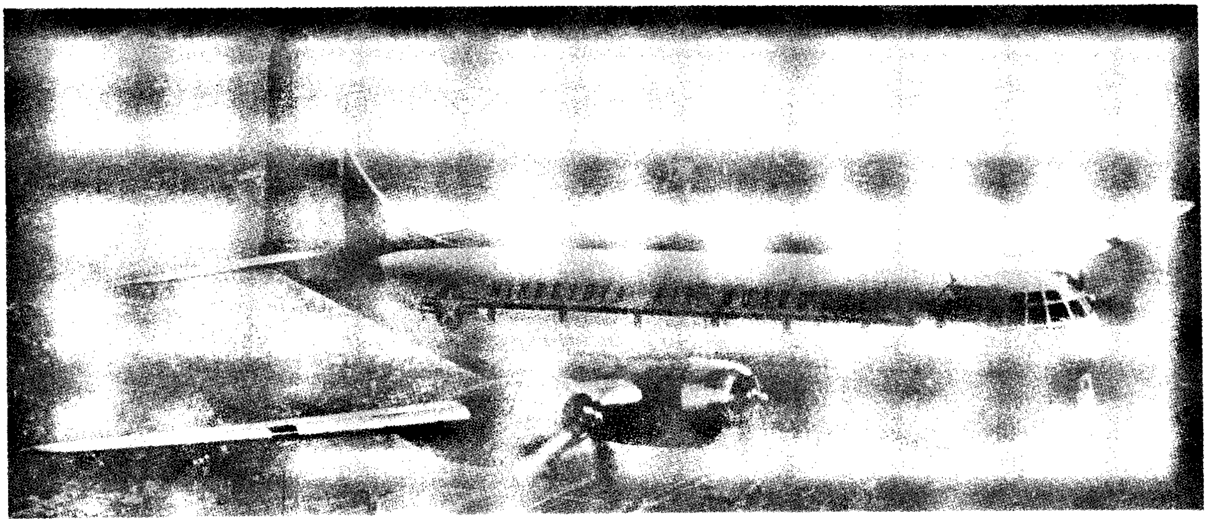

Figure 19–8. C–97 "Stratocruiser."

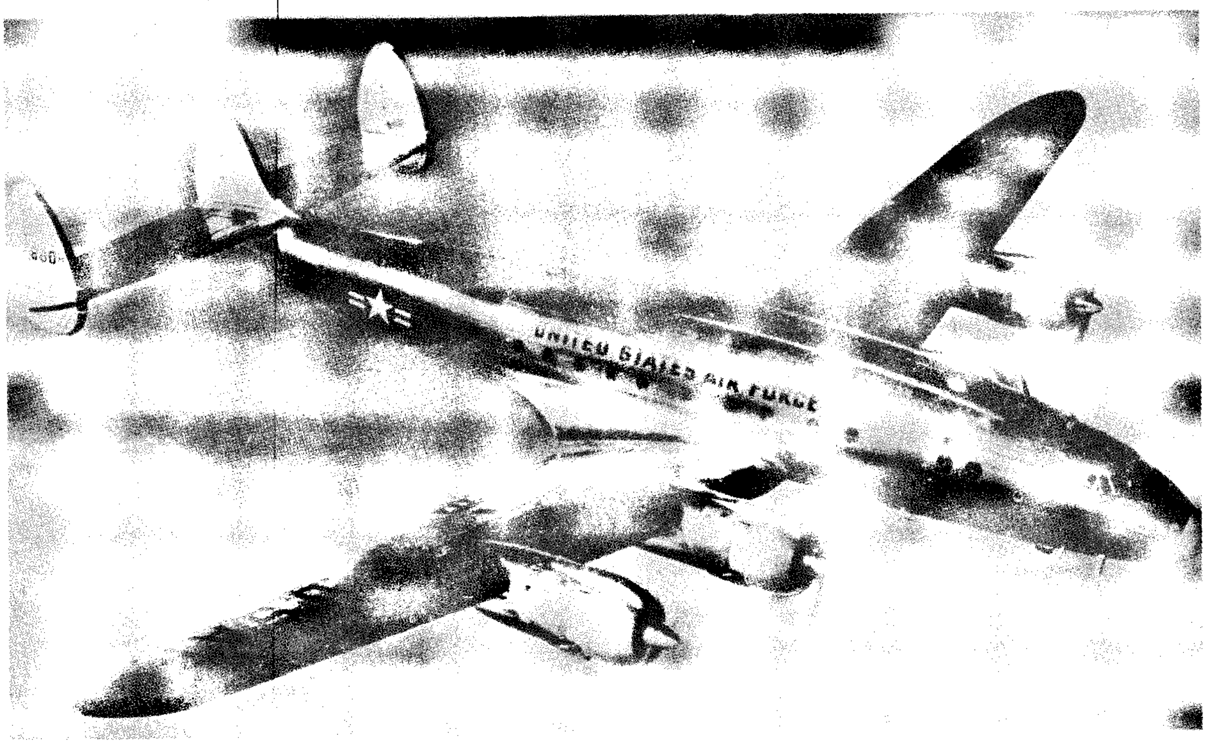

Figure 19–9. C–121 Lockheed "Constellation."

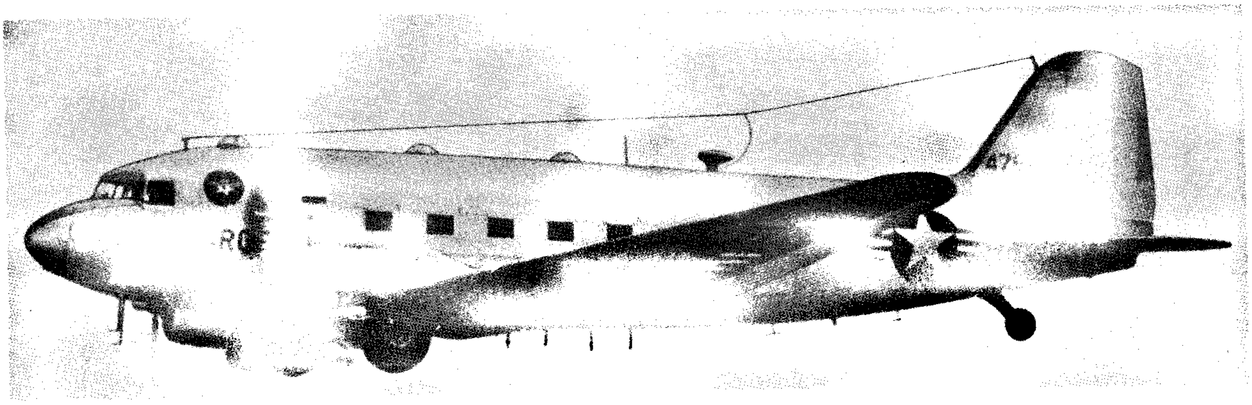

Figure 19-10. C-47 Douglas "Skytrain."

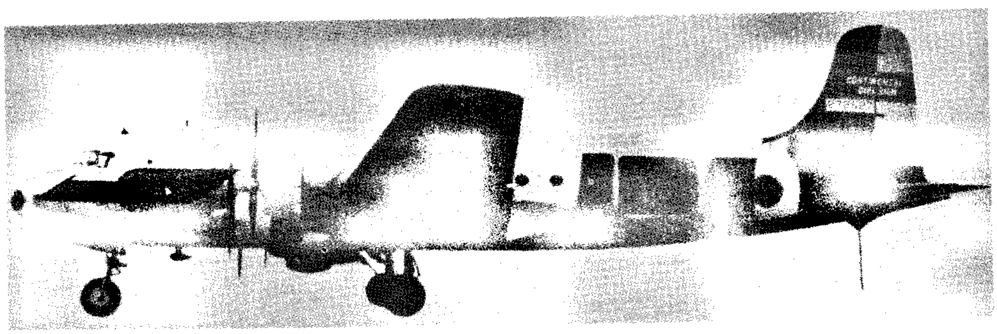

Figure 19-11. C-54 Douglas "Skymaster."

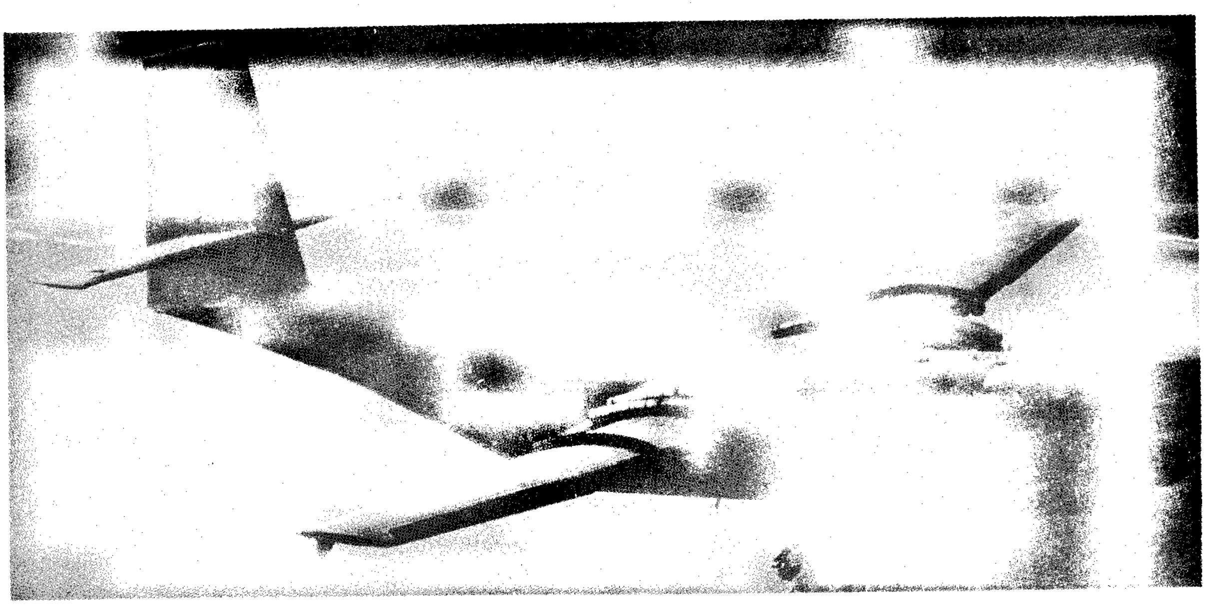

Figure 19-12. C-7 Caribou.

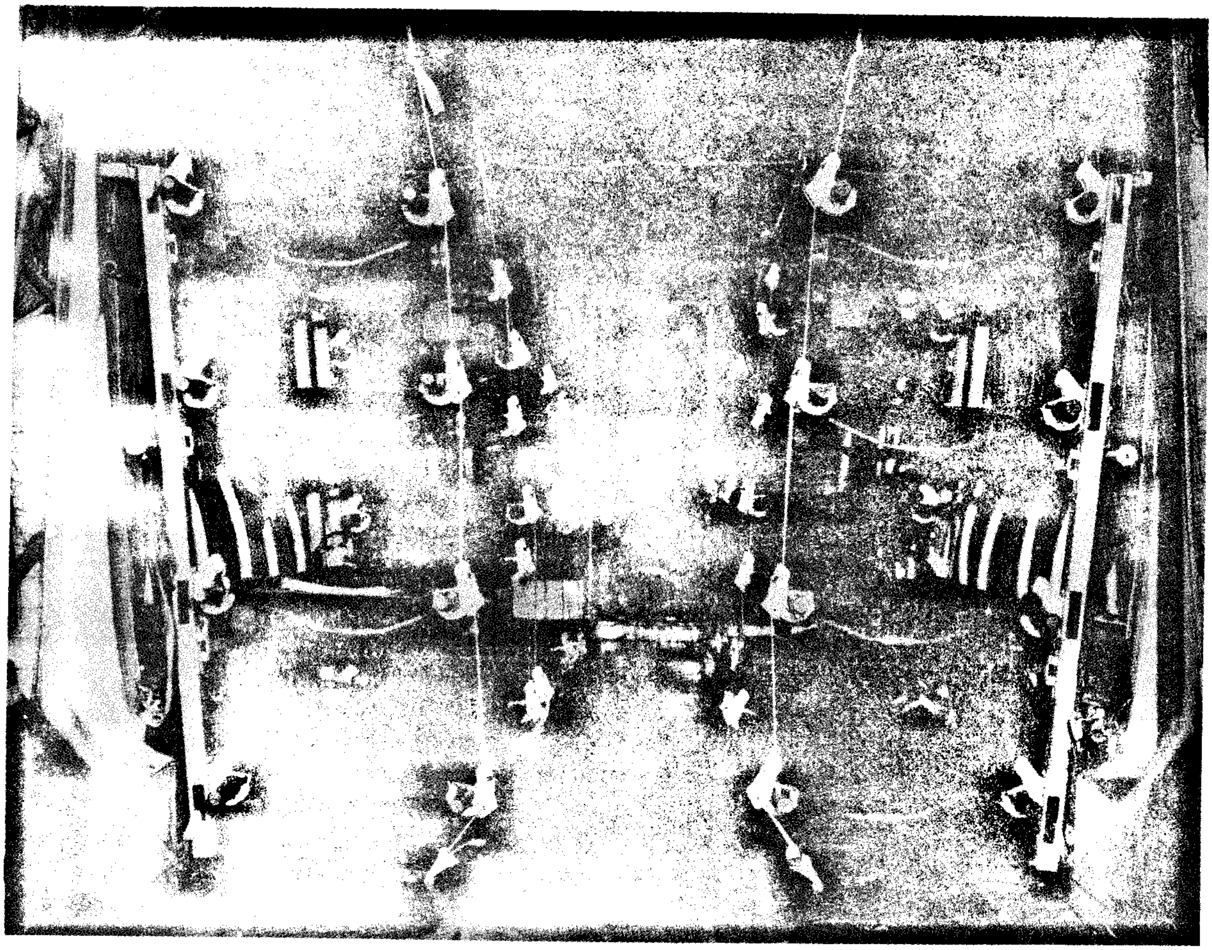

Figure 19-13. Interior View of C-7.

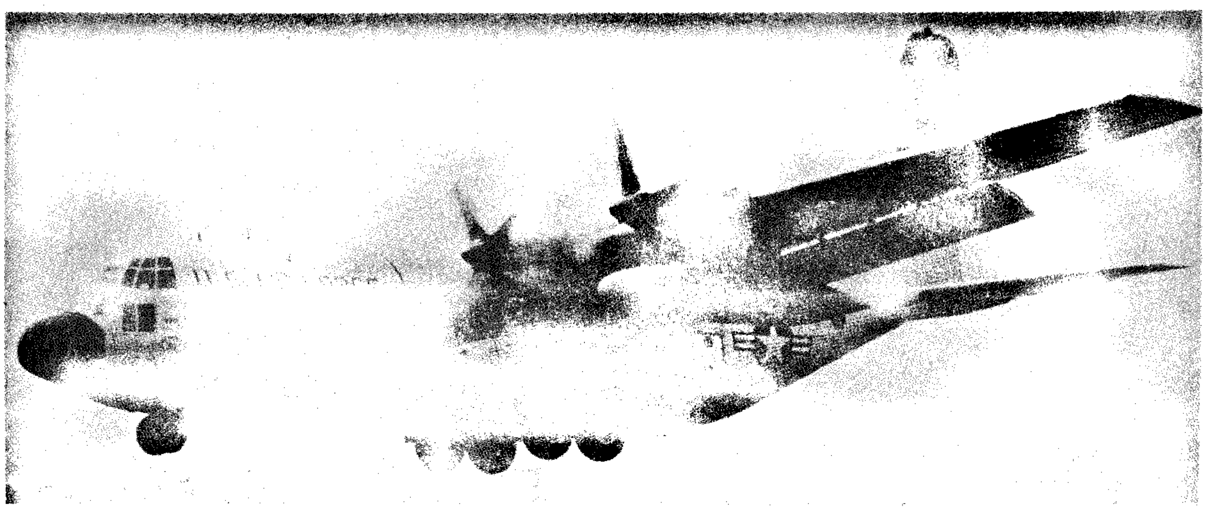

Figure 19-14. C-130E Lockheed "Hercules."

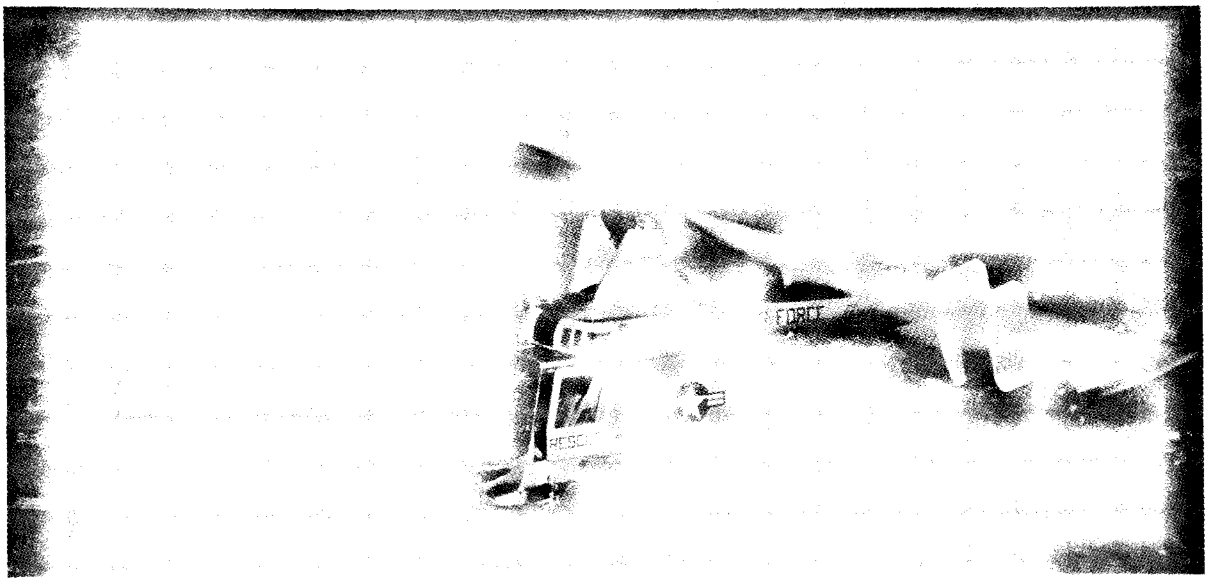

Figure 19-15. HH-43.

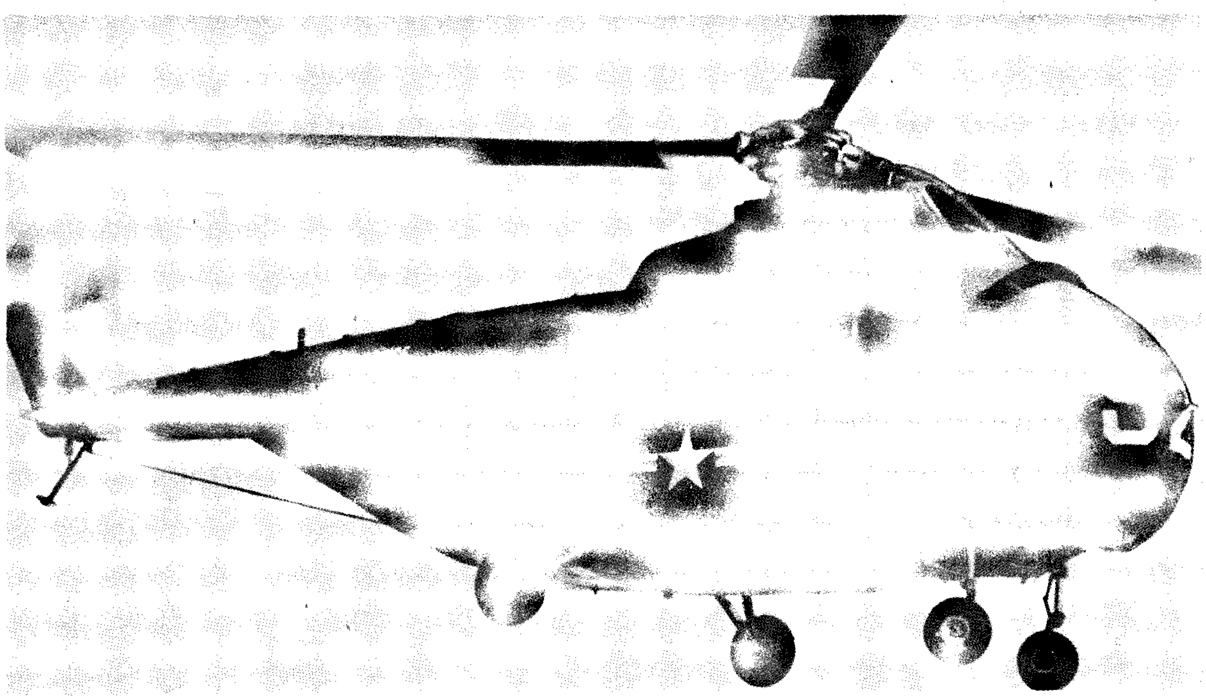

Figure 19-16. H-19 "Sikorsky" Helicopter.

such as those usually found in advance base operations. It can also carry heavy loads long distances without refueling. Power for this airplane is supplied by four turboprop, constant-speed engines.

Normal use is within a theater of operations.

The HH-43 (figure 19-15) is used primarily for firefighting in crash rescue. It normally carries a pilot and rescue crew of

HH-43

three, and can be configured to accommodate eight ambulatory or six litter patients.

H-19 "Sikorsky" Helicopter

The H-19 (figure 19-16) is a single-engine, single-rotor, three-blade helicopter that can accommodate six litter patients or eight to 10 ambulatory patients, depending upon their weight. Two tiers of three litters each are secured with standard webb support straps and wall brackets. Patients may be easily lifted directly into the aircraft.

C-9A

A significant milestone in the evacuation of sick and injured occurred when the C-9A was selected as the medium-sized jet aircraft for the domestic aeromedical evacuation mission. This intermediate range aircraft, the first specifically designed for the purpose of aeromedical evacuation, has the capacity of carrying 46 ambulatory or 40 litter patients, or various combinations.

The C-9A incorporates many features for providing greater comfort to patients and faster transfer from aerial ports to military hospitals close to the patients' homes. Configuration includes a special selfcontained, power-operated loading ramp and airstairs, an integral oxygen system to supply both emergency and therapeutic oxygen, a special patient-care area similar to hospital intensive-care units, flight nurse's station, two galleys, and storage areas for equipment, supplies and waste.

This aircraft contributes significantly to modernization efforts for the best possible service to our military personnel and their dependents.

CARE AND TREATMENT OF PATIENTS DURING FLIGHT

Experience has shown that almost every patient who can be evacuated by any available means can be evacuated by air, provided: the opportunity exists, the aircraft is suitably equipped with facilities, and the medical personnel aboard have a knowledge of the physiological changes of patients in flight. These changes are simple to understand. In cases where flight factors may involve either hardship or definite risk to the patient, physiological change can be minimized during flight if pressurized-cabin aircraft are used.

The principal changes in flight which may produce dangerous physiopathological states in the patient are: a. Decrease in the partial pressure of oxygen; and b. expansion of air or gas trapped in any body cavity.

Certain types of patients will require additional oxygen even at altitudes under 10,000 feet, due to hypoxia caused by disease or injury. Pulmonary edema or pneumonia may impede passage of oxygen to the blood. In the case of anemia or malaria, the transportation of oxygen may be inadequate. The entire column of blood may move too slowly to carry oxygen in sufficient quantity to the tissues, as in circulatory collapse caused by shock or cardiac failure. The tissues themselves may be so damaged that they are unable to use the oxygen, as in certain types of poisoning. Finally, thoracic injury may reduce ventilatory capability. Any one of these factors, added to the decrease in oxygen pressure on ascent, makes it necessary to supply supplementary oxygen from the time of takeoff.

Air or any gas trapped in the body cavities expands in direct proportion to the decrease in pressure. This increased volume becomes significant at 18,000 feet where the volume of air or gas in the body is doubled. Quite apart from intense discomfort and actual pain caused by certain types of injury, this expansion of gas at high altitude may constitute a real danger, as in the probability of rupturing a recently sutured intestine, and by the disturbance of cardiopulmonary dynamics in cases of pneumothorax.

AFR 164-1 presents very broad guidance with respect to the selection and screening of patients for aeromedical evacuation. This regulation also indicates the broad categories of cases that will require special consideration during evacuation. The specific nature of some of these considerations is presented in the following paragraphs.

Effects of Decreased Pressure

Gastrointestinal Tract Disturbances:

There are four principal factors associated with the production of abdominal symptoms on ascent to altitude. These are: a. The quantity of gas in the bowel, b. the cabin altitude attained which determines the amount of gas expansion, c. the ability of the bowel to eliminate the expanding gas, and d. the sensitivity of the bowel to pain.

In regard to quantity, most of the gas found in the gastrointestinal tract is believed to be swallowed air which is ingested with, or independent of, foods and fluids. Other sources of gas are the action of bacteria on food residues and gas diffusion from the blood stream. Patients who show apprehension and anxiety can quickly fill the stomach and colon with gas and experience a bloated feeling even at sea level. The chewing of gum before ascent to altitude should be restricted because, even though chewing gum helps to attain an equalization of gas pressures on the ear drum, large quantities of air may be swallowed with the saliva. An increased amount of gas in the bowel may also be associated with the ingestion of high carbohydrate diets, melons, and carbonated water.

It is quite possible that the site of a gas pocket in the gastrointestinal tract may be an important consideration in determining the degree of abdominal pain associated with ascent to altitude, since expansion of gas in the ileum has been shown to be attended by severe symptoms. It is also well known that distention of the duodenum results in a marked tendency to nausea and vomiting, which may be accompanied by a vasomotor phenomenon, such as a feeling of chill and cold sweat.

In theory, the expansion of gas at even a moderate altitude may be sufficient to cause rupture of a diseased viscus, especially in such cases as ulceration and weakening of the walls, as in peptic, typhoidal, amebic, and tuberculous ulcers located in various portions of the gastrointestinal tract. Some of these ulcerations are deep enough to leave the walls extremely thin, and, therefore, are subject to spontaneous perforation at ground level. Conceivably, gas expansion at altitude could, in borderline cases, exert enough pressure to break a thin wall. The ensuing dangers from chemical shock and peritonitis are obvious.

Patients with such conditions as strangulated hernia, meteorism of any type, intestinal obstruction, acute appendicitis, or diverticulitis are theoretically susceptible to complications if moderately high altitude must be attained in air evacuation. This reasoning may also apply to patients who have undergone recent gastrointestinal surgery in which the stomach or colon has been sutured. One should certainly consider the particular postoperative course of each patient and foresee the possible adverse effects of pressure changes on the suture line.

From the preceding discussions, it is possible to make the following generalizations that may be important in considering these patients for evacuation by air:

(1) Since the quantity of gas and the type of food ingested prior to flight may determine a difference in altitude tolerance as far as gastrointestinal symptoms are concerned, it seems reasonable to state that if, in the patient's experience, certain foods cause such symptomatic discomfort as distention, then, he should avoid these foods at ground level for at least 12 to 24 hours before a flight. Usually, a condition such as diarrhea, constipation, or other temporary gastrointestinal conditions will be aggravated and not relieved by ascent to altitude.

(2) When it is necessary to evacuate patients with gastrointestinal tract pathology, rectal tubes and stomach tubes should be available. It has also been recommended that, when patients have penetrating wounds or perforated ulcers of the stomach or intestine, use of the proper suction, as by the Wangensteen method, should be made to maintain intestinal tract decompression during flight. Occasionally, such simple meas-

ures as loosening tight belts, massage of the abdomen at altitude, and preflight lavatory hygiene are sufficient to prevent or relieve difficulties.

Very few, if any, symptoms have ever been reported as being of urinary bladder origin. It would seem that the bladder walls normally expand and contract in proportion to the urine content and, hence, there is very little or no free gas available for expansion at altitude. However, as a matter of speculation, a given patient with loss of bladder tonus, urinary retention, etc., could have difficulty if an increase in abdominal pressure were caused by expansion of gases in the gastrointestinal tract and this pressure were transmitted to the bladder. Obviously, recent bladder operations, fistulous connections, and temporary cystotomy with indwelling catheter could introduce sufficient air for expansion at altitude. If no arrangements for free release of the air were made, difficulties probably would arise.

Pathological Conditions of the Chest. There are a number of pathological conditions of the chest that may be responsible for a person's poor tolerance to evacuation by air.

Pneumothorax:

Although there are several types and classifications of pneumothorax injuries, all of them will have one thing in common. On ascent to altitude, any air trapped in the pleural cavity will expand and cause further collapse of the lung on the affected side and perhaps cause mediastinal shift. Analysis and understanding of several situations are important because they will provide a basis for explaining the effect of altitude on air in the pleural cavity.

A perforating injury of the chest wall allows air to enter the pleural cavity. This is an external pneumothorax, and if the defect is allowed to remain open, the air in the pleural space will be at atmospheric pressure (760 mm Hg at sea level). The presence of air at this pressure in the pleural space will prevent the lung from expanding during inspiration because there will be little or no difference between the air pressure on the outside of the body and the air pressure in the pleural cavity. Obviously, large openings may be more dangerous than small openings. Further, if the wound acts like a valve, allowing air to enter the pleural cavity but not leave it, then the air pressure in the cavity may rise above atmospheric and a "tension pneumothorax" results.

In some instances, the lung itself may become diseased so that there is erosion of a pulmonary bronchus. Under these conditions, the bronchus is in direct communication with the pleural space and air can enter the chest from the bronchus. This is an internal pneumothorax, but its effect, insofar as air is concerned, is no different from that of the external type. In both conditions, air at ambient pressure has entered the pleural cavity, limiting the expansion of the lung and, obviously, embarrassing respiration.

The important thing to remember is that, on ascent to altitude, gas in the pleural cavity will expand, and the expansion will be somewhat greater than that demanded by Boyle's Law for dry gases. The problem is much the same as that considered in the discussion of the gastrointestinal tract. When trapped gas in the pleural cavity expands at altitude, it will cause further compression of the lung on the affected side and may cause mediastinal shift or mediastinal flutter with each respiratory cycle. Because of this shift, function of the opposite lung may become impaired, and sudden death may result from impaired cardiac and pulmonary functions. Another possible, but less likely, complication is aero-embolism. Air trapped in the pleural space might expand and compress the affected lung's alveoli and, perhaps, tuberculous cavities so forcefully that air is forced from these spaces into the venous capillary blood vessels. Several studies have shown that a differential pressure of 80 or 100 mm Hg is needed to force air as bubbles from the alveoli into the blood stream.

Medical personnel should make certain that the proper instruments are at hand to aspirate air from the pleural cavity and, thereby, prevent air expansion at altitude. These instruments should be available under all circumstances because weather conditions are unpredictable and an unscheduled ascent to higher altitudes may become a necessity. These untoward effects may occur even though oxygen is used. This emphasizes that relief of hypoxia does not prevent the expansion of gas in the pleural cavity at altitude.

Mediastinal emphysema, arising from a direct puncture wound, perforation of the pharynx, esophagus, etc., could also produce serious effects on the circulation by causing pressure on the large veins which enter the chest. The expansion of this trapped mediastinal gas at altitude may result in further complications by exacerbating these pressure effects. Such patients certainly should not be evacuated by air unless a pressurized aircraft is available or unless an emergency situation demands immediate movement of the patient. In an emergency, the flight must be made at low altitude if a reliably pressurized aircraft is not available.

Tuberculosis:

Many military personnel with tuberculosis of varying degrees of clinical severity have been transported by air. Commercial aircraft have also transported thousands of tuberculous patients. There is no definite evidence that these patients were adversely affected by their exposure to altitude. However, each tuberculous patient to be evacuated by air must be considered a special case. The use of oxygen, special handling of coughed-up material, and the possibility of pneumothorax occurring during flight are considerations worthy of attention.

If moderately high altitudes (12,000 to 15,000 feet) must be attained during the flight, it is safest to use oxygen masks. A tuberculous lung may have a sufficient loss of surface area and restriction of movement by adhesions, so that symptoms of hypoxia would appear at altitudes lower than those in the case of a normal person. The use of oxygen may be especially indicated in tuberculous patients because, if hypoxia occurs, faster and deeper breathing could possibly cause hemorrhage by stretching healed lung fibrous tissue or the adhesions which are relatively common in chronic cases. Even though oxygen may be used, the apprehensive patient who becomes hyperpneic or the patient affected by moderately severe airsickness could possibly have a hemorrhage. This is also true of patients with bronchiectasis or esophageal varices.

The possible effects of gas expansion in body cavities have been discussed. It is important to point out again that, if air is trapped in a small cavity or in a small bronchus which is blocked, this air will attempt to expand at altitude. If the cavity has a rigid wall and does not readily allow an increase in volume, then the pressure inside the cavity or closed bronchus undergoes a relative increase at altitude. It is reasonable to believe that the expansion of gas in such a closed region or in and around a tubercle, under some circumstances, could liberate organisms into other areas of the lung. Material in the bronchi can be coughed up. This is not unusual in bronchiectasis or tuberculosis. It is obvious that disposable oxygen masks should be provided and other measures employed to prevent the spread of infective organisms.

Cranial Injuries:

Certain types of skull fracture cause injury extensive enough to result in the entrance of air into the brain case. This is particularly true if the fracture occurs in the bony wall between the sinuses, or ear, and the brain with a tear in the dura mater. In such cases, there may be a leakage of either clear or bloody cerebrospinal fluid to the outside. At the same time, of course, air can enter the skull. Because of blood clots and the possible valve-like action of damaged tissue, it is feasible that, in many instances, this air is relatively trapped and would expand at altitude if such a patient were evacuated in an aircraft.

The effects of such gas expansion could be expected to be far more serious than in other regions of the body because the brain is so rigidly inclosed that the gas attempting to expand could exert a considerable pressure. Harmful effects, and even death, may result from the expansion of intracranial gas.

It should be apparent from the preceding discussion that adverse effects of gas expansion may also be expected in the air evacuation of patients who recently had air artificially introduced into the skull or spinal spaces for purposes of encephalography or ventriculography. Similarly, brain tumors and cysts with spaces occupied by gas could produce symptoms of varying degree, depending upon the cabin altitude attained during the flight as well as the quantity of gas. One should be aware of the possible effects of altitude on such patients, and careful preflight evaluation should be made to determine the advisability of evacuating such patients by air.

It has been shown that, in the presence of brain concussion with an elevated cerebrospinal fluid pressure, there is a decreased oxygen saturation of the arterial blood. The latter hypoxemia could be alleviated by breathing oxygen. These findings provide a basis for advocating the use of oxygen equipment in the case of a patient with an elevated intracranial pressure who must be evacuated by air. A positive-negative pressure resuscitator should be used if there seems to be any danger of the patient's own respiration becoming embarrassed. The mean pressure during the respiratory cycle should be close to ambient pressure because higher pressures could further increase intracranial pressure.

Miscellaneous Conditions. Any collection of gas under the skin, as in subcutaneous emphysema, or in the muscles and skin, as produced by the anaerobic organisms, such as B. Tetanus or B. Welchii, may be expected to expand during ascent. Whether this expansion of subcutaneous gas would result in faster and wider dissemination of the organisms or toxins is problematical. Such a possibility exists, however, and should be carefully considered when the question arises regarding the advisability of evacuating these patients by air.

Dysbarism

At the altitudes used for air evacuation, symptoms of altitude dysbarism, such as bends and chokes, are not usually problems. However, one should be aware that persons with recently healed fractures can have moderately severe joint symptoms at low altitude. The occurrence of joint pains at these low altitudes suggests that other factors, such as hypoxia or vascular changes, are concerned in the production of "typical" bends pain—that is, in addition to "bubbles." Recent injuries, such as contusions, injection sites, etc., seem to become painful more frequently than old injuries.

Pregnancy

Patients who are beyond the 240th day of pregnancy normally are not accepted for evacuation by air. Exception may be made if movement is deemed essential. Theoretically, mild degrees of hypoxia at altitude, with changes in cardiovascular function and with, perhaps, a mild degree of change in acid-base balance because of hyperventilation, could cause an altered irritability of the uterus. Gas expansion in the stomach and colon could, perhaps, contribute to the total pressure of the already distended abdomen. It can be easily understood by those who have been moderately or severely airsick that repeated episodes of nausea, vomiting, and retching are undesirable symptoms, and would be especially undesirable if airsickness occurred during the last trimester of pregnancy.

Effects of Decreased Air Density

The effects of decreased air density are an important consideration in the evacuation of patients by air. The concepts are simple. Litter patients may require food and drink during flight. The reclining position is not conducive to efficiency in the act of swallowing. Consequently, there may be aspiration of a small amount of fluid or solid material into the trachea or bronchus.

Both at sea level and at altitude, the irritation of the respiratory passages caused by such foreign material results in reflex coughing. However, the effectiveness of the cough mechanism depends to a great extent, upon the density of air in the respiratory passages. Even at low altitudes, the air density has been sufficiently decreased so that the force of the expiratory phase of the cough is lessened. For this reason, the efficiency of the cough in removing such foreign particulate matter is decreased and the results may be disastrous.

Effects of Hypoxia

In general, the vulnerability of a patient to hypoxia at altitude would largely be a matter of the degree to which the patient cannot accommodate because of respiratory or cardiovascular pathology. This means that the respiratory apparatus, cardiovascular system, or both, fail to respond to the decreased oxygen tension at altitude. The patient is not as able to accommodate to the lower oxygen tensions as is the normal person.

Patients having pneumonia, emphysema, asthma, tuberculosis with extensive pulmonary adhesions, lung abscesses, or tumors, may already have the hypoxic type of hypoxia when they are at sea level. Ascent to altitude will add an additional degree of compromising hypoxia. Another case in point is that of the patient who has fractured ribs. It is obvious that the additional breathing response induced by the lowered oxygen tension at altitude would increase his discomfort by forcing him to breathe deeper and faster. Tight bandages may decrease his capacity to increase pulmonary ventilation.

All of these patients will normally benefit at altitude by the administration of oxygen. The benefit should be noticed quickly.

One simple fact which seems to be obvious, but nevertheless is often forgotten is: That, for oxygen administered by mask to be effective, the airway must be patent. The administration of oxygen by mask to a patient with a severe edema of the vocal cords or a severe degree of pulmonary pathology may not result in the desired oxygenation of the blood. Obstruction of the respiratory passages at any point between the mouth and nose to the alveoli will prevent the administered oxygen from reaching the pulmonary capillaries. Oxygen cannot, in these cases, be expected to provide relief from hypoxia.

At cabin altitudes attained during the usual or even unusual air evacuation flights, if the patient is initiating his own inspiratory efforts, there is little need for the additional oxygen that may be supplied by pressure breathing. The use of a pressure breather by patients at the low cabin altitudes of current aeromedical evacuation aircraft would be advantageous only if the patient were so severely ill that his spontaneous respirations ceased. Obviously, in this case, the pressure breather must be a resuscitator type of apparatus—that is, the instrument cycles whether or not the patient is initiating spontaneous respirations. One must understand that the instrument delivers a positive pressure which serves to inflate the lungs, and that this pressure is over and above the ambient or environmental pressure.

Air Transportation of Patients With Respiratory Insufficiency

In transporting patients with respiratory insufficiency, the physician is faced with two major problems: a. The criteria to be used in selecting patients for air transportation; and b. adapting currently used methods in the treatment of respiratory insufficiency to the limitations of air travel, to insure adequate care of the patient. The simplest way to discuss these problems is to separate the movement of these patients into three phases, namely, *preflight, in-flight,* and *postflight.*

Preflight:

This phase is the most critical. The selection of patients is of paramount importance. The adverse effect of physical activity on morbidity and mortality has been demonstrated. Thus, as a general rule, only a patient whose condition has stabilized and who is past the acute stage is acceptable. In exceptional cases, when respirator care is not available locally and cannot be taken to the patient, it may be necessary to transport such a patient to a respirator center.

This still leaves a large group of postacute or early chronic cases of poliomyelitis who may require transportation to a rehabilitation center, a larger hospital, or their homes. With respect to this group, the extent of the respiratory paralysis is important in determining how the individual patient will be transported and what margin of safety is available. A patient with only moderate respiratory paralysis, who is out of the respirator 8 to 12 hours a day, can usually be moved safely by ambulance or train for relatively short distances. More severely involved patients can be moved more safely and quickly by air.

It is the responsibility of the physician in charge of the patient being transported to make certain that the patient will receive the same quality of care in the aircraft as that provided in the hospital. This includes the proper instruction of those attending the patient regarding routine and special orders, and precautions to be taken to insure stability of the patient's well-being while in flight. All nurses should be alerted to the care of tracheostomies and the use of respirators. As a rule, a chest film is obtained within 24 hours prior to flight to assist in the evaluation of the patient.

In-Flight:

The in-flight phase presents other problems. The conditions of dryness of the atmosphere and the decreased oxygen tension at cabin altitude of 6,000 or 7,000 feet constitute hazards for the patient. The dry atmosphere causes thickening of the patient's secretions which makes their removal difficult. This can be combated by frequent suctioning, by intratracheal lavage with normal saline, and by humidifying devices. Decreased density of the air at altitude makes for less efficient functioning of the respirator. This, together with the decreased oxygen tension, may lead to serious underventilation. To avoid hypoventilation, the patient's tidal volume and respiratory rate are checked at frequent intervals, especially after any change in cabin altitude, and the respirator is readjusted as necessary.

According to the Radford nomogram, an additional 5% is added to the tidal volume for each 2,000 feet of cabin altitude above sea level. As a secondary check, the pulse and blood pressure are recorded at more frequent intervals between ventilatory measurements. A rise of over 20 mm mercury in the systolic pressure, or an increase of 20 to 30 beats per minute in the pulse rate may indicate hypoxia, which requires an immediate check of tidal volume and respiratory rate. The patient is given humidified oxygen if necessary, but an adequate ventilatory minute volume is essential whether oxygen is given or not. Patient anxiety related to the flight is allayed as far as possible by constant attendance and reassurance. Antinauseants are used if airsickness occurs, and often are given one hour before flight in selected cases.

Postflight. In the postflight phase, patient care remains under the supervision of the flight team until the patient has been placed in a respirator at the receiving hospital, and his ventilation, pulse rate, blood pressure, and general condition are considered satisfactory. (A certain number of these patients will develop complications after flight, such as fever, pneumonia, atelectasis, or excessive secretions. The incidence of such complications, however, has appeared to decrease considerably with the improvement in technique for air transport.)

By constant attention to the criteria for patient transportability and by continual refinement of in-flight procedures, a safe and practical method for transporting patients with respiratory insufficiency can be maintained.

Responsibilities of Originating Hospital:

The attending physician should have a tracheotomy performed in advance of the flight if there are any bulbar signs present, other than isolated facial nerve paresis.

The staff should be available to assist in the transfer of the patient from hospital equipment to a portable respirator.

The physician in charge of the patient should be available to brief the Air Force medical team on the patient's condition.

All medical records and clinical charts should be available.

The patient's baggage and equipment should be ready for movement.

Responsibilities of Destination Hospital:

Upon arrival of the patient, the receiving staff should be available and should include a physician who will become familiar with the case.

Personnel who are knowledgeable in the mechanics of the respirator should be available in the event there are mechanical difficulties requiring their attention.

Spare respirators should be available for emergencies or as replacements for malfunctioning units.

Hyperventilation Syndrome. Hyperventilation due to anxiety may result in respiratory alkalosis, with the patient exhibiting symptoms of blurring of vision, tingling of the fingers, and dizziness, which may progress to loss of consciousness, carpopedal spasm, and convulsions. Reassurance is important and may prevent this sequence of events. However, the physician must keep in mind that hypoxia may lead to hyperventilation which, in turn, may result in hypocapnia and the symptoms noted above.

Air Transportation of Patients With Cardiovascular Disease

The circulation has **three compensatory** mechanisms for increasing oxygen transport when hypoxic stresses are placed on the body. These mechanisms are: a. Increasing cardiac output; b. increasing the arterial-venous oxygen difference; and c. increasing the amount of circulating hemoglobin.

An important point to be made is that one of the compensating mechanisms for altitude hypoxia may be an increased cardiac output. At ordinary altitudes, the cardiac output may increase to about six liters per minute at rest. Even mild exercise at altitude could call for a further increase in cardiac output. Obviously, this means an increased strain on the heart and vascular system.

Patients with decompensating hypertensive cardiovascular disease, recent coronary occlusions, or angina pectoris should ordinarily be declared unacceptable for air evacuation except in emergencies when pressurized cabins are available. Most hypertensive patients can be transported safely; however, when factors such as apprehension and the presence of arteriosclerosis are considered, it may be better, sometimes, to err on the side of conservatism and not put the increased strain of altitude hypoxia on the diseased system. In any event, each case should be evaluated individually.

Anemia

The anemic patient differs from the normal patient in that he has a smaller total oxygen capacity and a smaller total oxygen content. One should not be misled by the fact that the anemic person can have the same oxygen saturation as the normal person. It is obvious, however, that the patient who is anemic by 50% has only half the amount of oxygen available to the normal person, even though the saturations are the same.

In a very anemic person, the tissues usually suffer because they do not remove 6 volumes percent of oxygen from the arterial blood, but perhaps only remove 2 or 3 cc of oxygen from each 100 cc of blood. Perhaps the tissues acclimatize, to get along on less oxygen. In any event, it is certainly obvious that there are limits on the extent to which his cardiac output, increased A–V difference, and mobilization of hemoglobin can help him to adapt to increased oxygen need during exercise or ascent to altitude.

As far as evacuation by air is concerned, it may be indicated that the anemic person be given oxygen.

As a general **rule, if his body at rest is** compensating for his anemia and keeping him in fairly good condition at sea level, then the administration of oxygen to such a person at moderate altitudes should keep him in just as good a condition at altitude as he was at ground level. By supplying him with oxygen at altitude, it is possible to make certain that what hemoglobin he does have is 100% saturated.

Sicklemia and Splenic Infarction

Since 1947, more than 30 cases exhibiting sicklemia and splenic infarction associated with aerial flights have been reported in literature. At present, a sickle cell preparation is required on members of ethnic groups known to have a high incidence of abnormal hemoglobin before flying status is approved. Consideration is being given, however, to establishing some form of electrophoretic hemoglobin analysis as a routine screening procedure.

Special Care of Eye Cases

The management of various diseases and injuries of the eye deserves special consideration because of its importance in helping to preserve useful vision or even the globe itself. The facts must also be known to make the proper selection of eye patients who may be evacuated safely by air.

It must be remembered that, ordinarily, the eye is a liquid-filled organ that is not subject to expansion changes. However, in injured and surgical cases, air may be present from injury or may have been surgically injected to reform the anterior chamber. In these cases, the patient must be flown at low altitudes to prevent the air from expanding and reopening the wound or breaking surgically sutured wounds. The alternative and best method is to transport the patient in a pressurized cabin with an especially low cabin altitude.

The effects of hypoxia are also important. Hypoxia produces dilatation of the retinal and choroidal vessels. A person who has had an intraocular hemorrhage may have a recurrence of this hemorrhage if not properly managed. Therefore, oxygen should be administered in such cases when attaining cabin altitudes of 4,000 feet and higher.

Hypoxia also produces a rise in intraocular tension. This is not desirable in any type of eye patient and can be prevented by the administration of oxygen.

A third important change in the eye caused by hypoxia is a decrease in pupillary diameter. This is particularly bad in injured or surgical cases where it is desired that the pupil remain dilated. This can also be prevented by the administration of oxygen.

A fourth point to bear in mind is the fact that the retina has the highest oxygen demand of any organ in the body. Therefore, in any type of choroidal/retinal disease or injury, oxygen should be administered, beginning at 4,000 feet, to prevent further damage to these tissues by the lack of oxygen. Sedation is important in relieving nervous tension in cases such as glaucoma.

In deciding whether the eye patient should be a seat or litter patient, the following may be helpful: The eye patient should be a litter patient if he has had: a. Recent intraocular wound; b. recent intraocular surgery; or c. severe eye disease of any type.

In managing the patient en route, care must be taken to prevent squeezing of the injured globe. Thus, dressings must be applied lightly and 0.5 percent tetracaine hydrochloride eye drops (Pontocaine) may be instilled every hour. *No eye ointment should be used in any open eye wound* since severe intraocular damage is often caused by entrance of the ointment through the wound. The patient should be heavily sedated with barbiturates. Morphine must not be administered without the permission of an ophthalmologist because it produces pupillary constriction.

The comatose patient must be carefully watched to prevent corneal drying. This can be prevented by closing the lids and holding them with moist cotton pledgets or by covering the eyes with X-ray paper after removing the emulsion. This paper, cut to proper shape, can be formed into a cone to be placed over the eye.

In caring for eye patients, the following danger signs must be watched for, and if they occur, they should be carefully noted on the patient's flight record: (1) Severe pain; (2) blurring or loss of vision; (3) visible intraocular hemorrhage; (4) change in pupillary size or shape; (5) photophobia; (6) protrusion of the globe; (7) extreme redness of the eyeball and conjunctiva; and (8) marked tenderness of the globe.

Decrease in Temperature at Altitude

In the case of patients at altitude, one should consider the type of aircraft used in air evacuation, and the range of temperatures likely to be encountered.

It is wise to make certain that the proper number of blankets and other necessary items are available for the protection of patients in the event that heating systems fail or high altitudes must be attained. Usually, the heating system is adequate, especially for patients situated forward in the aircraft. A common observation has been that the rear areas of some military aircraft are often not too well heated and, under some conditions, are uncomfortably cold.

Airsickness

Any type of motion sickness results in distress. There is reason to believe that patients transported by air are more likely to become airsick than other passengers. All grades of distress are encountered. Since airsickness may occur at any altitude, the problem is much different from that of hypoxia or dysbarism where decreases in altitude are usually effective in alleviating the condition. The most prominent symptoms of airsickness are nausea and vasomotor phenomena, such as pallor, sweating, chill, and actual vomiting.

The patients to whom vomiting is a particular danger are those with injuries requiring intermaxillary fixation. Usually, such patients are not transported by air unless the tie-wires are cut or replaced by elastic bands. When they are transported with tie-wires in place, they must be watched very closely and a proper instrument must be at hand to release the wires if necessary. They may also be further aided by being placed in a position that will facilitate removal of vomited material, which, as mentioned previously, is very important to all airsick patients.

Airsickness in severely ill patients or those with recent abdominal operations requiring extensive suturing procedures is highly undesirable, as the act of vomiting and retching causes increased tension on abdominal muscles and considerable increases in intra-abdominal pressure. It is reasonable to surmise that weak suture lines could be affected.

REFERENCES

The reader should insure the currency of listed references.

AFM 2–4, *Tactical Air Force Operations—Tactical Airlift.*

AFP 160–5–15, *Poliomyelitis.*

AFP 160–5–16, *Acute Renal Failure.*

AFP 160–6–9, *Care of Patients With Injuries of the Spinal Cord.*

AFP 161–16, *Physiology of Flight.*

AFR 160–12, *Professional Policies and Procedures.*

AFR 164–1, *Worldwide Aeromedical Evacuation.*