Experiences in Air Transportation of Patients with War Wounds of the Chest*

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During the early days of the Pacific war and the battle for the Solomons the first mass air evacuation of casualties was attempted by U. S. Marine Corps Transports. During a period of five months an estimated 12,000 casualties were flown to hospitals five hours distant. Quoting from an article by Flaherty, T. T., Yavorsky, Wm. O., Yood, N. L. and McWilliams, Jos. G., published in the July 1943 issue of the Naval Medical Bulletin, the following comments concerning air transport of chest wounds are worth noting:

"Many chest wounds have been evacuated by air. In most instances the specific type of injury is not known by the flight surgeon on the plane. On the whole, only moderate dyspnea has been encountered below 400 feet. Oxygen has been used only with dyspnea and not prophylactically. With chest cases flights have been made at altitudes below 1000 feet unless weather conditions demanded higher altitudes for safety of the ship."

In this discussion one death was reported in a patient with a left hemothorax flown at an altitude of 4000 feet for two hours. Sudden dyspnea and collapse occurred which was found on autopsy to be due to further intrathoracic hemorrhage occurring in flight. An attempt to give plasma failed, aboard the plane, due to collapse of the veins.

From another article by McMahon, Alphonse, and Huston, H. R., in the November issue of the same periodical entitled, "War Wounds of the Chest," I extract the following:

(a) Two hundred seventy-eight cases of war wounds of the chest were encountered at a U. S. N. Base Hospital in the South Pacific.

(b) Of the total number 81 were classed as perforating wounds of the chest with primary manifestations in the pleural cavity as pneumothorax, hemothorax, hemothorax; or the secondary evidence of empyema and pleural effusion. Eighteen of these were complicated by multiple wounds elsewhere in the body. Six of the 81 cases succumbed to the injury. Inasmuch as this hospital, not named in the article, was the first base hospital south of the Solomons and received nearly all of its patients by air

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during the early months of the Solomons campaign, it may be assumed that nearly all of the total of 278 cases were flown in.

In January 1944, the writer was sent out into the Pacific Theatre to organize and to direct a medical group to be engaged in evacuation of non-effective sick and wounded by air transport. During the battles for Iwo Jima and Okinawa approximately 15,000 battle injuries, and non-effective sick were flown from these two target areas to Naval and Army hospitals in the Mariannas. Among the patients carried by Air Transport were injuries of every description, which involved all portions of the body, and followed the usual percentage distribution of battle wounds in this war, with wounds of the extremities occurring with greatest frequency, followed by wounds of the abdomen and torso and head and neck in decreasing frequency. In the fiercely contested battle for the heavily Jap garrisoned island area of Iwo Jima and the Okinawa groups, the one thing which could be said characterizing battle wounds was that all of them were of more than usual severity.

The causative agents were, quite typically: first in frequency, fragments from mortar and hand grenades, followed by rifle and machine gun projectiles, the heavy mortar and shell missiles, and finally, bayonet wounds. Enemy sharpshooters were numerous, well dug in, and perfectly camouflaged, so that the percentage of wounds caused by rifle fire was higher than in almost any other battles of the Pacific, and accounts for a higher than normal incidence of wounds of head and neck and upper or (exposed) parts of the chest.

During the Iwo campaign one squadron of Navy R4D Transports and one of Navy's PBM (sea planes) were employed as Task Group 94.12, responsible for air evacuation. The medical staff then consisted of five medical officers, three Hospital Corps officers, twenty-four flight nurses and twenty-four Hospital Corps men. One medical officer (F.S.) and three hospital corps assistants were dispatched to the target area to set up a screening and loading unit. This unit had the responsibility for receiving casualties from the Casualty Air Evacuation Hospital near the Air Field, reviewing of casualty tags and medical records, and issuance of instructions for the care of each patient while enroute by air to the Mariannas. Flight nurses and hospital corpsmen were to see all cases with him before embarkation, and were instructed as to any expected or possible emergencies. Any routine medications were to be continued in flight. These consisted of administration of sulfa drugs, penicillin, plasma, serum albumen, whole blood, oxygen inhalation, sedatives, etc.

After conclusion of the Iwo Jima operation the total responsibility for air evacuation of non-effective sick personnel and battle
casualties, Pacific areas, was assumed as a function of Naval Air Transport, Pacific Wing, for the Navy, and Air Evacuation Group One was set up at Guam. The administrative details of this organization are not described in this article because of later reorganization. Air Evacuation Group One included the following medical components: “One Captain, MC, USN, as staff medical officer; Six flight surgeons, ranking from Lieutenant to Lieutenant Commander, USN and USNR; Four Hospital Corps officers of the rank of Lieutenant or Lieutenant (junior grade); Eighty-five flight nurses, five of whom had the rank of chief nurse; One hundred and fifty-six flight hospital corpsmen.”

Air Evacuation Group One was supplied with Douglas Sky-masters, long-range, four-engined transports similar to those employed by the Air Transport Command and Naval Air Transport Service for long distance cargo and passenger hauling. Those assigned to the air evacuation schedules were equipped with webbing strap litter supports for twenty-eight litter borne patients. Additional seats for four ambulatory patients were also provided. In addition to the regular crew, a flight nurse and a flight hospital corpsman accompanied each trip. Medical equipment and supplies comprised the following items:

(a) One air-borne medical chest, weighing about 70 pounds, containing dressings, instruments, medicines, bed pans, urinals, catheters, etc.

(b) One refrigerated whole blood chest, containing two units each of whole blood, plasma, albumen, and a supply of distilled water and penicillin.

(c) Boxed aviation flight rations were placed aboard each plane just before departure for the target, and consisted of canned fruit juices, soups, and bouillons, crackers, tomato juice, tinned boned chicken, turkey, and tuna, candy, chewing gum, cigarettes and other miscellany. In addition, a carton containing loaves of bread, paper cups, and feeding tubes or bent straws was added. Thermos jugs containing hot coffee and cold water were carried. The fresh water tanks of the plane also were filled before each trip. Two electric hot cups at 12-24 volts were carried in the medical chest.

(d) Twenty-eight steel-poled or aluminum-poled litters were carried, as well as three blankets per patient. These were off-loaded at the target in exchange for loaded litters, and blankets. After a 1,500 mile return trip of about 7½ hours duration, the patients were disembarked at the Naval Air Evacuation Center at Agana Field, Guam. The unloading was quickly accomplished by roll-a-way step ladder, followed by the unloading of litter cases by roll-a-way two stage loading platform or by finger-lift truck.
All types of injuries were accepted and transported. Only one patient from Iwo Jima and only two from Okinawa died during the trips by plane. In none of these was it considered that conditions peculiar to air travel were responsible for the fatal termination. In the beginning of our operations the screening officer at the target accepted no early chest wounds and only those abdominal wounds which had been successfully operated upon and were well stabilized postoperative cases. During periods of intensive battle with overloads of casualties, it became necessary to transport casualties only a few hours after being wounded. The only criterion used in screening at such intervals was this question: "Is this patient in condition to survive transportation by any means, land, sea, or air?" Patients with continued hemorrhage; in shock; or badly exsanguinated were held for treatment by shock team before being sent out.

Chest penetrating wounds were accepted if there was no marked dyspnea and the patient was reasonably comfortable. Pilots were advised when carrying such loads of casualties not to exceed 2000 feet altitude and flight medical attendants were told to employ oxygen if dyspnea or signs of anoxia developed. One of the two patients who died had a bullet wound through the base of the skull and after ten days in the hospital on Okinawa was sent over for air evacuation suffering from an unrecognized bilateral bronchopneumonia. This patient arrived at Guam in a moribund condition and expired three hours later in Fleet Hospital No. 111. Necropsy disclosed the pneumonia and a basilar brain abscess.

As was intimated earlier in this paper, certain criteria were set up during the first days of our operations. Perforating wounds of the abdomen were not considered good risks for air travel until at least eight to ten days after operation. Penetrating wounds of the chest, with complicating hemorrhage or pneumothorax, and mediastinal injuries were (upon the advice of several early writers on the subject), considered as not suitable cases for air travel. Then, suddenly we were called upon to meet military necessities as they occurred. We were frequently confronted with the choice of moving such patients to the hospitals 1500 miles away, where the best of equipment and skill awaited, or of leaving them to be carted back miles to already overloaded medical facilities not too far behind the line of battle. There was no real choice. We adopted the relatively simple criterion of asking ourselves, "Is this patient capable of being moved by any of the available means of transportation with a fair chance of surviving the trip?" So we began moving recent chest injuries, abdominal injuries, compound fractures, often supported only by temporary splint-
ings, and burned cases, out of the battle area and to the hospital 1500 miles away, and we found that they not only survived the trip but frequently arrived in the Mariannas in better condition than when we first examined them in Okinawa and in Iwo Jima. Out of perhaps 500 chest injuries of all grades of severity and with all of the usual complications, not one died enroute, and I do not believe that the $7\frac{1}{2}$ hours of air travel seriously affected the eventual prognosis of any of them.

**Physiological Considerations Imposed in Flight**

There are several things which were overlooked by the excellent physiologists, internists, surgeons, and chest men, who had predicted dire results if certain categories of injuries were transported by air. Allow me to explain a few of the overlooked factors:

1. First, it was not foreseen that in flying for great distances over open seas, in certain ocean areas and in most seasons of the year there are no violent storm areas which must be flown through. Consequently our flights could be set up for either 6000 feet or at 2000 feet, above or below the usual levels of slight turbulence. Several plane loads of most critical cases from Iwo Jima were flown the entire distance back to Guam at 600 to 800 feet. Altitudes up to 2000 feet do not produce anoxia through lowering of the partial oxygen pressure of inspired atmospheric air. It should be explained at this point that air transport of chest injuries over land does not permit of maintaining a constant altitude of 2000 to 3000 feet due to the nature of the terrain. Natural obstructions, such as mountain ranges and high plateaus require altitudes of 8000 to 12000 feet for crossing. No measurable degree of physiological oxygen want has been demonstrated at altitudes up to 5000 feet although there may be some slight effect. Oxygen breathing equipment for aircraft use is set so that the partial pressure of $O_2$ supplied shall not be reduced at any time below the 5000 foot altitude equivalent. Reduction in absolute atmospheric pressure, too, at the scheduled flight altitudes in the Pacific could not exert any considerable change in volume or pressure of any entrapped gases in lung spaces or in the intestines. Thus all of the physiological objections to moving patients in these categories by aircraft were at once obviated by the selection of lower altitudes for return flights of air transports carrying such cases. These objections certainly would have to be considered, however, in any overland transfer of such cases.

In the summer and fall of 1945 a great many patients were flown back to the States and to Pearl Harbor from Naval Hospitals in the Philippines and from the Admiralty Islands. The question was raised as to possibility of air evacuation of tubercu-
losis cases. The answer was as in previous instances—yes, these cases can be transferred by plane, subject to the following exceptions: (a) Pneumothorax was not to be performed within seventy-two hours prior to the flight, and (b) cases with demonstrable cavitation or prone to hemorrhage were not to be accepted. Pilots were advised to use minimum safe altitude and plane loads of these patients went through at 2500 to 3000 feet altitude. No untoward reactions were observed except that these patients occasionally showed cyanosis and dyspnea even at relatively low flight altitudes. When oxygen was administered the cyanosis and dyspnea disappeared. It would appear on the basis of this experience that cases of pulmonary tuberculosis without cavitation and not too recently relaxed by artificial pneumothorax may be safely transported by air at altitudes not exceeding 3000 feet. Medical attendants should accompany such cases in the event of rapidly developing cyanosis or dyspnea. Oxygen, of course, should always be available. Sedation was almost routinely employed by Naval Hospitals in the Philippines in preparation for the trip.

REFERENCES

Discussion
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The transport by aircraft of large numbers of injured and sick personnel during the recent war arose out of military necessity. The war throughout was one in which our military forces were committed to attacking and defeating an enemy already in possession of large or small land areas, which, in most instances,
he was well prepared to defend. Our repeated invasions over beach-heads held by our enemies necessitated the development of an entirely new method of attack combining air, sea and ground forces, which became known as amphibious warfare.

Amphibious warfare, or attack on enemy shores from the sea, presupposes or requires the following conditions: (1) That our naval forces can maintain control against enemy naval forces of the sea lanes of approach. (2) Combined naval, air and ground force coordination in attacking enemy shores and in sufficient force so that beach-heads can be held against any possible enemy attack during the subsequent movement of men, munitions and supplies into the area. (3) Heavy casualties must be expected which must be moved quickly and in large numbers from the beach-head over considerable distances back to the supporting bases where our attacking forces have been concentrated and where adequate facilities for their medical and surgical care have been prepared prior to the final movement forward. Such movement of casualties must be accomplished by hospital ships, hospital transport vessels, and large transport type aircraft properly modified and equipped for such employment and manned by well trained medical and hospital corps personnel.