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by

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CASUALTY EVACUATION BY AIR

with special reference

to the Campaign in North Western Europe.

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The object of this thesis is to present the principles of Casualty Air Evacuation in some of their administrative, surgical, medical, and psychological aspects. An attempt will be made to apply the knowledge gained in war during the liberation of Europe, to the conditions of peace. The conclusions reached are based on my experience of over 20,000 casualties successfully evacuated by air.

INTRODUCTION.

EVACUATION OF CASUALTIES IN WAR.

Before proceeding to the evacuation of casualties by any one specific method, it is essential to obtain a wide conception, by considering the general principles of the different methods and comparing their relative advantages and disadvantages.

The evacuation of sick and wounded from any theatre of active warfare is naturally a major medical administrative problem, but in addition its tactical significance can not be overlooked. Reviewing the channels which exist for evacuation, it is found that they are:-

(1). Road, by Motor Ambulance.

(2). Rail, by Hospital Train.

(3). Sea, by Hospital Ship.

(4). Air, by Transport Aircraft.

It will be observed that the expression 'Transport Aircraft' and not 'Hospital Aircraft' is used because in war the aircraft did not carry Red Cross markings, and were therefore legitimately subject to attack by hostile aircraft. Their primary functions were to carry airborne troops, to tow gliders, and to bring forward urgent freight and personnel. The transport of casualties on the return flight was of secondary importance, militarily, if not medically. Whether special hospital aircraft protected by the Geneva Convention should have been provided, or will be provided in a future scheme, is a moot point and one with which many controversial features are associated (1).

Among the many factors to be considered in planning the evacuation of battle casualties, including sick, are:-

(1). The number of casualties expected from the military operation.

(2). The evacuation routes readily available.

(3). The geographical nature of the country in which the campaign is being fought.

(4). The prevailing climatic conditions likely to be encountered.

(5). The facilities which are known to exist for the establishment, near to the fighting zone, of large medical units such as large General Hospitals with their highly specialised branches, such as Neurosurgical and Faciomaxillary Units.

(6). The distance between the forward areas and the Base Hospital zones where full facilities exist for the complete treatment and rehabilitation of every case.

(7). The relative time involved in transporting casualties to the base zones, with the most satisfactory results to themselves, by the different methods considered. It must be continually borne in mind that speedy evacuation of many cases tends to result in their becoming fit for duty in a much shorter time than would otherwise be possible. This is a feature of paramount importance where trained, highly-skilled manpower is at a premium.

(8). The existence of evacuation ports, airfields, or locations on which it has been planned to establish airfields in captured territory, from which it will be operationally possible to evacuate casualties in large numbers.

(9) /

(9). The availability of Hospital Ships or other suitable shipping, and the availability of sufficient and suitable transport aircraft.

(10). The best method of fully utilising the available medical resources by speedy distribution of casualties from busy forward zones to less busy rear areas.

(11). The necessity of having in existence a reserve chain of evacuation in case of a partial or complete breakdown in the main chain due to a combination of unforeseen circumstances.

Bearing these factors in mind, it is now possible to assess the values of the different methods - road, rail, sea, and air, and to arrive at certain fundamental conclusions.

For the evacuation of casualties in the actual battle areas, motor transport, including if necessary tracked light armoured vehicles, is the only method excepting stretcher bearers. Evacuation along good roads over distances of up to 50 miles in ambulance cars is satisfactory, if necessarily somewhat slow. Weather has no effect on its efficiency and staging is possible.

For longer distances by land with a good existing rail net-work, hospital trains are more economical in time and man power, and more comfortable than motor ambulances. The medical facilities are also much better. Staging is again possible and once more evacuation is unaffected by the vagaries of the weather.

Evacuation by sea is influenced by port facilities, the availability of shipping, the weather, and the duration of the voyage. Long sea voyages are slow, and there are more suitable settings/

settings for operative surgery than on a hospital ship. This surgery is more likely to be necessary because of the duration of the voyage. For operated, fully treated, or convalescent cases it is ideal if the time factor is not important.

The essentials of air evacuation are an airfield, a supply of suitable aircraft and satisfactory weather. Staging at airports en route, mainly in close proximity to general hospitals, is possible.

ADVANTAGES OF AIR TRANSPORT.

Assuming that undoubted aerial supremacy has been secured, air evacuation is the method of choice of all evacuation over 100 miles, especially if sea crossings have to be made. The advantages to be derived from air transport are:-

(1). The saving in general evacuation time and more especially the saving in transit time. (General evacuation time is considered to represent the number of hours from the time of injury or onset of illness to the time of arrival at a Base Hospital: transit time, the time taken in transit between one hospital and another).

(2). The saving of man-power.

(3). The comparative ease of loading.

(4). The absence of repeated handling.

(5). The relative smoothness of air travel.

(6). The comparative safety of travel by such means.

(7). The uplift in morale caused by the novelty of air travel.

(8). The fact that as a method of transportation it is is equally good for operated and non-operated surgery over journeys of up to 500 miles.

(9)/

(9). The probability of suitable staging being possible.

(10). The economy of the load.

(11). The assistance it gives by diminishing the shipping and transport necessary to carry stores and medical equipment forward, especially if the lines of communication are long.

DISADVANTAGES OF AIR TRANSPORT.

The disadvantages undoubtedly are:-

(1). The weather, which is being partially overcome by the increasing use of Radar, but which still causes delays.

(2). The normal risks of air transport, and the fact that in the event of a forced landing away from an airfield medical attention may not readily be available, and it may be difficult to obtain sufficient road ambulances for the onward transmission of the casualties.

(3). The difficulty of using it as (i) the sole method of evacuation, or (ii) if aerial supremacy is not established.

(4). The selection of casualties in the event of the aircraft having to fly at altitudes of over 10,000 feet, or in very rough weather.

A BRIEF ELABORATION OF THE ADVANTAGES AND DISADVANTAGES of EVACUATION BY AIR.

Having outlined in general the advantages and disadvantages of air evacuation, a few specific examples will serve to clarify the reasons.

The time-saving element is adequately illustrated in the case of A.B. who was injured in a motor accident. After orthopaedic/

orthopaedic treatment under anaesthesia and the application of a plaster cast, he was evacuated from an airfield in Normandy to a Base Hospital in England. He arrived in the latter hospital within 6 hours of his injury. This is by no means an isolated case and demonstrates the saving in general evacuation time.

As an example of the saving in transit time, it is sufficient to state that many hundreds of casualties from Canadian Army Hospitals in Nijmegen were having a meal in England 4½ hours later, while awaiting distribution to Base Hospitals in the United Kingdom. (2). The same journey by rail and sea would have taken 2 to 3 days and a large percentage of the casualties could not have stood the journey.

Thousands of less seriously ill patients leaving Nijmegen hospitals were in hospital in Bruges 2½ hours later, before their next injections of Penicillin were due. This diminution in transit time is beneficial to all types of casualties, but particularly to the more serious cases.

The saving of man-power would not appear obvious, but is nevertheless a fact.

Clark R. L. Jr. and Shands A. R. Jr. (3) quote the following information from the South West Pacific theatre:-

Fourteen large four-engine aircraft could transport the equivalent to six 500 bed Hospital Ships. Travel time was cut from 24 days to 39 hours. Crew and medical personnel were reduced from 2136 for the ships to 336 for air transport .

The/

The loading of an aircraft is easy. The ambulance cars are driven to within three yards of the aircraft, and from then onwards the loading of 24 casualties by a party of 8 men can be completed in 10 minutes, including the necessary documentation. Handling of stretchers is reduced to a minimum, and disturbance of casualties is less likely to occur than by any other method.

Air travel is normally smooth. There is usually little jolting on taxying, take-off, or landing. In the air, straps can be affixed to the stretchers to protect the patients in really rough weather, but it is extremely rarely that casualties can not be flown because of 'bumpy' weather.

One hundred stretcher casualties questioned on whether there was more discomfort attached to one hour's air passage, or to a similar time spent in an ambulance, produced the following replies:-

92 stated less discomfort by air.

5 thought there was little difference.

3 preferred the road journey.

Two of the last 3 had been airsick! The hundred patients had experienced different weather conditions and varying road surfaces, and included four different nationalities. It is interesting to note that Aird in a Honyman Gillespie lecture suggested air transport as a solution to the long comfortless evacuation line in the desert. (4).

On the safety of air transport, little need be written. Eighty-two thousand casualties evacuated from North West Europe to the United Kingdom from D-Day to VE-Day without

one/

one accident to a patient suggests that there is no safer way.

Base or 'Blighty' has great significance to a battle casualty, and the novelty of getting there quickly, in comfort, by air has a beneficial effect on his morale.

Patients who had undergone little or no operative treatment, as were encountered in Normandy in June 1944, travelled just as well as the fully treated cases flown back to the United Kingdom later in the campaign, provided that they were kept free from pain. I cannot help feeling that the casualties evacuated at the same time in Landing Ship Tanks from the Normandy beaches were less fortunate, if only because of the length of transit time.

Staging of casualties was used to good effect in the early Spring of 1946 when casualties from Germany were flown to Brussels, staged, and then transferred to the United Kingdom. It is practicable, and of value, when long flights are necessary with seriously ill patients.

Several benefits accrue from what was described earlier as economy of load. The load (24 patients) is all that one doctor, nursing sister, or nursing orderly can contend with. It is neither too many, nor too few. Only if several seriously ill cases are being transported may it be too many.

In the event of an emergency landing or diversion to another airfield, all R.A.F. Stations are capable of dealing with one load and arranging their onward transmission. The size of the load ensures rapid handling and distribution

of/

general evacuation time in comparison with evacuation by land and sea.

There are two important provisions:-

The first is that the cases have been fully treated surgically and further operation is unlikely to be necessary at an early date. It is preferable that they remain in hospital until a few hours before their evacuation.

The second is that the hospitals in question are not compelled to evacuate to make way for other casualties. If this is not necessary, the casualties suffer little inconvenience from the delay, and in any case benefit from the shortened time in transit. Delay is only detrimental to unoperated surgical cases such as might be evacuated early from a bridgehead. Weather unsuitable for flying and lasting over two days was infrequent in North West Europe from June, 1944, to May, 1945.

The vagaries of weather which prohibit air evacuation are not therefore in any way detrimental to the treated patient, though they may well be to the untreated one. Where the weather question becomes really important is when for long periods, due to climatic conditions, bad flying weather prevails. In such circumstances one can only hope to use air evacuation, when available, as a secondary method for high priority cases, or to ease the strain on the primary channel.

The increasing efficiency of blind-flying equipment must also be considered, and the day may not be far distant when it will be as justifiable to fly casualties in foggy weather as in cloudless skies.

The risk associated with flying in war is probably less for a casualty than an ordinary passenger, despite the absence/

absence of Red Cross markings on the aircraft. Risks in war may be justified to deliver urgent passengers to their destination, but they could not be considered for casualties. Besides, the human element, so important in the causation of accidents, seems to be influenced beneficially when a crew is flying wounded.

Air evacuation can rarely be used as the sole chain of evacuation because of the possibility of a peak casualty period coinciding with a spell of bad weather. This applies more to forward areas than to base zones, and does not in any way prohibit its use as the primary method from other than front-line medical units. Selection of casualties for air evacuation, as will be found later, does not constitute a major drawback, provided a doctor with a little experience is in charge.

Balancing the pros and cons, there is no doubt that the advantages of air evacuation outweigh its disadvantages for all journeys of over 100 miles distance.

THE HISTORY OF AIR EVACUATION BEFORE THE WAR AND DURING THE YEARS 1939 to 1946.

It is felt that without an historical outline of the birth and progress of air evacuation, misunderstandings of its problems might arise in the mind of the reader. This seems to necessitate the inclusion of a section on 'The History of Air Evacuation'.

To those with knowledge of aerial transportation it may seem extraneous; to those without, it should prove interesting and not without medical significance.

As/

As it belongs to the realm of administrative medicine, a sphere of topical interest at present, it is written without apology.

Prior to the beginning of the war in 1939, the Royal Air Force had flown casualties on a small scale in different theatres, and during the war a scheme was operated in England whereby casualties could be transported by air to different hospitals.

The figures of casualties evacuated during the year 1940 were about 300, and for 1941 about 2,000. Evacuation on a large scale did not commence until the campaign of Libya and the Western Desert. In November and December, 1942, the numbers flown in that theatre were 5,000 to 6,000 per month. In the year 1943, 28,000 casualties were air evacuated, mainly from the M.E.F. This year also saw the development of casualty air evacuation units and sections.

In the following year, with the invasion of Europe, even larger numbers were evacuated across the Channel from France. By the second week of August, 1944, the daily total of casualties evacuated by air exceeded those evacuated by sea. After September until the end of the campaign, except for two short lapses in October and November, the numbers evacuated by air were persistently higher than those evacuated by sea.

The break-out from the Normandy beach-head in August saw the institution of a forward shuttle service, This service resulted in 42,000 casualties having the benefit of speedy travel from forward to base Continental airfields between August, 1944, and May, 1945.

Between/

Between June, 1944, and VE-Day, 82,000 casualties were evacuated to the United Kingdom from the Continent.

In the year 1944, 300,000 casualties in all were flown by the Royal Air Force in all theatres.

Sixty percent of all British casualties in North West Europe were brought to the United Kingdom by air, but in the Far East, in forward areas, the figure reached almost 100%. The chances of survival were naturally increased for tens of thousands of casualties. (5).

THE DEVELOPMENT OF AIR EVACUATION IN ENGLAND AND NORTH WEST EUROPE FROM SEPTR., 1943, UNTIL MAY, 1946.

For simplicity, this development will be described under four general headings:-

(1). The formation of Air Evacuation Units in England and their functions, taking into consideration the policy of the period Septr. 1943 to June, 1944. Mention will be made in this sub-section of the formation and broad general principles involved in the establishment of reception units in the United Kingdom.

(2). Air Evacuation from Normandy.

(3). Air Evacuation throughout the remainder of the campaign and the institution of the Forward Shuttle Service. A broad outline of the period August, 1944, to May, 1945.

(4). Evacuation from the Continent after the conclusion of hostilities - May, 1945, to May, 1946.

(1). THE FORMATION OF CASUALTY AIR EVACUATION UNITS IN ENGLAND AND THEIR FUNCTIONS, TAKING INTO CONSIDERATION THE POLICY OF THE PERIOD SEPTEMBER, 1943, to JUNE, 1944.

The planning and training of Units naturally began considerably before D-Day, and was based primarily on experience gained in the Middle East. In September, 1943, the first Air Evacuation Units to be used for the despatching of casualties from North West Europe were formed in England. These Casualty Air Evacuation Units (C.A.E.U.), as they were named, were four in number. The units were part of the medical organisation of the Second Tactical Air Force, and two were established in each of the Force's two Fighter Groups.

These units consisted of a Medical Officer and 35 men. Sufficient transport and equipment was provided to make the unit completely mobile and self-supporting. The casualty holding capacity was 50 casualties. Medical equipment was comprehensive and included air ambulance panniers and oxygen apparatus.

The Nursing Orderlies of these units had to attend a course on Air Ambulance duties, and were qualified as Air Ambulance Orderlies. All Unit personnel were given instruction on stretcher handling, aircraft loading, and elementary First Aid and other courses, which embraced theory and its practical application. Over 60% were qualified to drive heavy vehicles and had passed road tests. Considerable time was devoted to pitching and striking canvas quickly, as accommodation for casualties as well as Unit personnel was all tented. Exercises were organised which stressed/

stressed initiative and mobility. The experience gained on such schemes proved extremely useful in the early phase of the invasion.

In the beginning of February, 1944, the four Units were transferred from Tactical Air Force control and incorporated into larger units known as Forward Staging Posts (F.S.P.), which were forming at this time in Transport Command. The main functions of these F.S.P's were to service and maintain transport aircraft, to receive and despatch passengers and freight, and to despatch casualties. The medical staff was essentially the same as that of the original Air Evacuation Units, except for the addition of one Medical Officer and two Nursing Sisters. The previous scale of medical equipment for a C.A.E.U. had been so comprehensive that there was little necessity to add materially to it.

At the same time as this was happening in Transport Command, one air evacuation unit had again been established in each of the 2nd T.A.F. Fighter Groups to replace the two which had been transferred and incorporated into the F.S.P's. These new C.A.E.U's, however, were formed this time in such a way as to be divisable into two sections or flights, each with a Medical Officer, 17 airmen, stores, transport, and being capable of working independently.

Further intensive training in the field in the winter and spring of 1944, and courses of instruction both by medical sections of F.S.P's and the modified, newly formed C.A.E.U's of 2nd T.A.F. resulted in an adaptable and efficient casualty air evacuation despatch service being

ready/

ready for the invasion of Europe.

At the same time in the South of England, casualty reception units were being set up at the three main terminal transport airfields. These units had facilities for holding and distributing 300-400 casualties per day. The airfields were well situated in the centre of an area in which many hospitals were available, and in addition were near to an excellent rail-head from which the lower priority casualties could be distributed by hospital trains when necessary. (2).

An operating theatre and a surgeon were available on the airfields to deal with all surgical emergencies. At one of these airfields there was a pool of 35 fully trained male and female air ambulance orderlies with experience of flying. These orderlies' work was to fly out with freight-carrying aircraft and to provide medical attention for casualties on the return flight.

These units, which were of necessity large, had two medical officers, a surgeon, 6 - 8 nursing sisters, and about 60 N.C.O's and other ranks originally. Their accommodation and equipment were amply sufficient. Some of the accommodation was originally tented, but later all casualty holding wards were hutted.

The reception and distribution of casualties was given a successful and comprehensive trial in pre-D-Day exercises. R.A.M.C. Officers attended those exercises. The aircraft to be used were demonstrated and the air evacuation plan was outlined to them .

The/

The original plan as it was conceived before D-Day was that in the initial stages of the campaign the Dakota aircraft which had carried freight or personnel from the United Kingdom to North West Europe would be loaded with casualties on the return flight. At this stage freight-carrying aircraft would be landing on congested, highly operational fighter strips, and would have to rendezvous with fighter escorts for the return journey, so that little time would be available for casualty loading. It was therefore exceedingly important that casualties should be awaiting the aircraft as they landed, and that trained loading parties should be standing by at readiness.

The Dakota aircraft was capable of carrying a maximum of 24 casualties, of which not more than 18 could be stretcher cases. The 18 stretchers were carried 9 on each side of the aircraft in banks of 3, the lowest stretcher of each bank on the floor, and the other 2 on racks. A subsequent modification to the stretcher racks made it possible to carry 21 lying patients instead of the 18 mentioned previously, and 24 if they were on the American type litter. The total load was never supposed to exceed 24 however.

Obviously, at this period an attempt would be necessary to mark and afford priority air travel to certain types of casualty when circumstances permitted, and sufficient aircraft were not available for the transportation of all the casualties. The priority grading mainly depended on the severity of the injuries and whether they would require

subsequent/

Pictorial representation of the conceived organisation of air evacuation during the early part of the Invasion of Europe.

subsequent treatment at specialised Neuro-surgical, Orthopaedic, Chest or Peripheral-nerve Centres.

It was considered that the despatching Air Evacuation Unit would probably be static and that the Officer in Charge would be in communication with the hospitals in the vicinity, either by telephone, or despatch rider, so that casualties could be called forward to await the arrival of the aircraft. In actuality, it never happened like this.

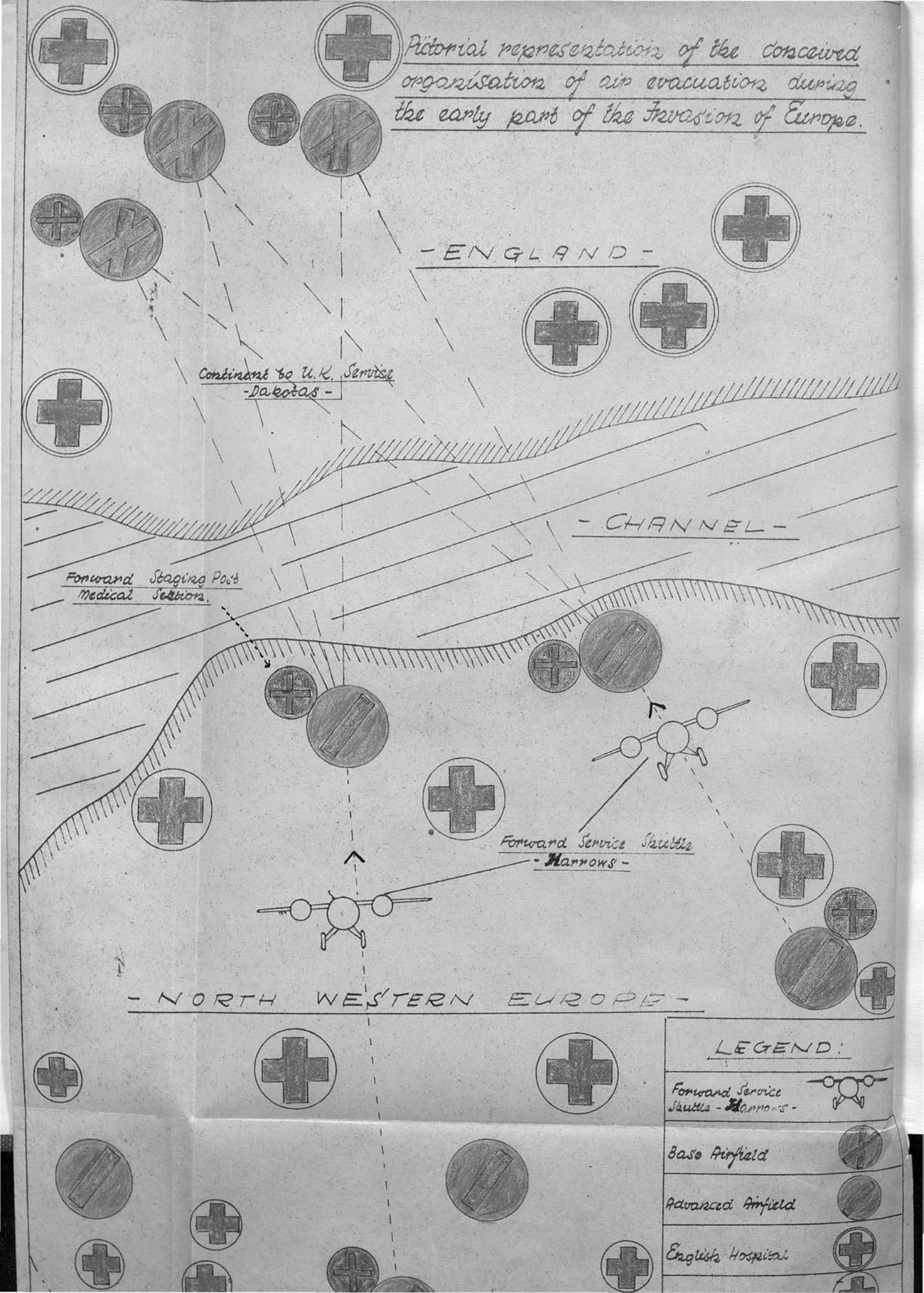
A pictorial representation is helpful in explaining the conceived organisation. (Diagram 1).

After a bridgehead had been established and broken out of, it was anticipated that a forward shuttle service would commence. The Air Evacuation Units of the 2nd Tactical Air Force Fighter Groups were to be located on forward fighter airfields within 10 to 20 miles of the fighting troops. The service was to operate between those forward airfields and Continental base airfields.

Obsolescent Harrow aircraft, unarmed, twin engined, high winged monoplanes with fixed under-carriages were to be used for this task. These aircraft had the great advantage of only needing a short runway for take-off, and compared favourably in speed and endurance with the Dakotas already mentioned. They had been renamed Sparrows after conversion to hold ten stretcher cases and fourteen sitting, twentyfour sitting, or thirteen stretcher with no sitting. The most economical pay-load was, obviously, ten stretcher cases and fourteen sitting.

The shuttle service was to be of short duration, up to one hour, and the aircraft were to carry a nursing orderly.

Six/


Pictorial representation of the conceived organisation of air evacuation during the early part of the Invasion of Europe.
-ENGLAND-
Continent to U.K. Service
-Dakotas-
-CHANNEL-
Forward Staging Post
Medical Section.
Forward Service Shuttle
-Harrows-
-NORTH WESTERN EUROPE-
LEGEND:
Forward Service Shuttle - Harrows -
Base Airfield
Advanced Airfield
English Hospital

Six such aircraft were available, primarily for the transport of casualties on the forward shuttle service. At the base Continental airfields, the F.S.P's would be situated and casualties staged by their medical sections before being transferred to base hospitals in the vicinity by road, or to hospitals in England by Dakota aircraft, of which there would be a plentiful supply.

Such then was the general plan for air evacuation when the invasion of Europe began.

Again a pictorial representation makes the situation more clear. (Diagram 2).

(2). AIR EVACUATION FROM NORMANDY.

In the early hours of the Normandy invasion, 30 R.A.M.C. surgeons landed behind the invading forces. By excellent surgical technique they saved the lives of many of those who could not stand evacuation, and by rapid yet careful selection of cases they cleared the beaches of every casualty which had a reasonable chance of reaching England alive. The evacuation was carried out by amphibious vehicles to specially equipped L.S.T's until July 14th, when it was supplemented by air evacuation.

No air evacuation unit was then present in the sector, and the medical officers of fighter wings, with scratch teams of stretcher bearers assisted by the aircrews of transport aircraft, loaded the Dakotas. In addition, a medical officer and such airmen as could be spared from a R.A.F. Mobile Field Hospital (M.F.H.) (6) which was in Normandy at the time, formed a mobile loading team.

A/

A R.A.M.C. Officer, known as a Medical Air Liaison Officer (M.A.L.O.) entered the picture about this time. This officer acted as a link between the Army medical formations and the R.A.F. evacuation units. He obtained daily figures to be evacuated from the various Army units, Casualty Clearing Stations, and Forward Dressing Stations, informing them of the number of casualties to be sent, the time at which to send them, and the location of the airfields from which they would be evacuated. The estimated time of arrival (E.T.A.) of the aircraft was known to him in advance, and it was his main responsibility to see that the casualties arrived before the aircraft. It was important that they should arrive before the aircraft so that they could be classified and marshalled into groups of ambulances, each group with sufficient to load an aircraft. Loading parties were at readiness by their groups of ambulances, and as soon as the aircraft were off-loaded, casualty loading began speedily and in an orderly fashion. Time for loading was always short and if casualties arrived late, conditions tended to become difficult.

Unfortunately, weather conditions and other factors often delayed the arrival of freighters, so casualties sometimes spent a few hours waiting on airfields. Arrangements were made for feeding them, giving plasma if required, and continuing the exhibition of routine sulpha drugs and morphine. Limited supplies of penicillin were available at this time, and this problem did not add itself to the many others confronting the Medical Officer in Charge.

The/

The biggest disadvantage was the lack of holding accommodation for casualties, which resulted in the immobilisation of ambulances for long periods. These ambulances were often needed for other purposes, and were not over plentiful in supply. The problem was never completely solved until the arrival by air at the end of June of a F.S.P. medical section with adequate staff and tentage. An F.D.S.* set up on an airfield as a stop-gap to hold casualties prior to this, was not of such great assistance as had been imagined because of the repeated changes in the scene of air evacuation from day to day.

On D plus 9, one medical officer and 8 men, half of a Tactical Air Force Casualty Air Evacuation Unit, with one three-ton truck loaded to capacity, left the embarkation area for the Continent. Within two hours of leaving the transit camp in Normandy, two days later, a centre for casualty despatch was established on a Fighter airfield. Casualties began to arrive very soon after (within two hours). The tented accommodation at its disposal was insufficient to deal with the numbers involved, and casualties had to be held in ambulances. The very seriously ill patients were removed under canvas, so that they could be better observed and treated. Air evacuation took place from this airfield on several days, but the weather it will be remembered, was extremely troublesome at this time and it did not reach the standard of efficiency that had been hoped for.

On D plus 14 this centre was closed and the personnel joined another small formation of roughly the same strength on another airfield. This latter formation actually consisted of one medical officer and 12 men, mainly from the R.A.F.

Hospital/

* Field Dressing Station.

Hospital mentioned previously.

On this airfield, the efficiency of Chrysarobin in curing Psoriasis gained this unit the valuable assistance of a Norman peasant boy. Later, with his friend, he became an unofficial member of the unit. They were excellent workers and proved of inestimable value in stretcher bearing. Their propensities for 'winning' the foodstuffs in short supply were astounding. Subsequently, though quite illegally, they saw the whole of the campaign through to the Luneburg Heath before being unofficially demobilised.

As airfields were constructed, the Dakotas flew in the advanced parties of Fighter Wings, and the joint air evacuation unit mentioned above, of two medical officers and twenty-two men, arrived previously to establish a centre from which to load aircraft. Almost daily movements through the coastal area, sometimes by night in clouds of artificial smoke, were trying, but the difficulties were overcome on most occasions by the unstinted co-operation of everyone concerned.

About this time a hospital area with several General Hospitals functioning initially as C.C.S's had been established in Bayeux and casualties were able to be held there.

As an illustration of the times and the improvised procedure used, it is of interest to describe one memorable day towards the very end of June. The Unit, which was resting at the time, moved at half an hour's notice to an airfield to which 40 Dakotas had been routed. Twenty were to arrive in the morning, and twenty in the afternoon. The time available for off-loading freight and on-loading casualties/

casualties was one hour and twenty minutes in both cases, as a fighter escort was being provided.

The casualties began to arrive just as the tentage had been erected and the cookhouse established. The casualties were checked, and two moribund head injuries removed; both subsequently died. As the aircraft taxied in, a list was prepared of the aircraft numbers. The ambulances, which had previously had their contents marked in chalk on the mudguard, were each directed in turn to a specific aircraft. The drivers were given a slip of paper with the aircraft number so that there could be no mistake. By this means a steady and controlled flow was maintained to each aircraft. By the time twemty ambulances had been directed to a different aircraft each, the off-loading of the first ambulance had been completed into the first aircraft and its loading team were waiting for a further supply. The controller of the ambulances jotted down opposite the aircraft numbers on his sheet the number of casualties sent to each aircraft, so that he had a check throughout the whole loading procedure. This method was the only way in which the aircraft could be loaded in time. One member of the air evacuation unit supervised the loading party of each aircraft. These parties consisted of fitters, riggers,drivers, in fact anyone with time to spare was pressed into service, but the aircrews themselves gave invaluable assistance. Some pilots were warming up their starboard engines while casualties were being loaded on the port side. Seven hundred casualties sent by the various hospitals were all evacuated, and none died en route to the United Kingdom.

The/

Detailed Schematic of R.A.F. Air Evacuation Representation holding Centre at B 14 Bazville Normandy

LATRINE

AIRMEN'S LINES

COOK-HOUSE

STRETCHER CASES

FROM REVIERS

NO ENTRY

STRETCHER CASES

R.A.F. AMBULANCE PARKING AREA

STRETCHER CASES

WALKING WOUNDED AND CINEMA

LATRINE

LATRINE

OFFICER'S LINES

OFFICE

ORCHARD

THEATRE

ANAESTHETIC Room

STERILISING ROOM

SISTER'S LINES

MOBILE POWER TENDER

AMBULANCE CHECK POINT "IN"

PRIVATE ROAD FROM AIR EVACUATION CENTRE TO AIRCRAFT DISPERSALS

VEHICLE DISPERSALS

LEGEND:

CIRCUIT IN AND OUT OF ARMY AMBULANCES FROM REVIERS AREA

CIRCUIT IN AND OUT OF ARMY AMBULANCES FROM BAYEUX

CIRCUIT OF R.A.F. AMBULANCES FROM AIR EVACUATION CENTRE TO AIRCRAFT DISPERSALS

FIG. 4

Air Evacuation Centre and its relation to aircraft dispersals

B 14 Barville (Diagramatic)

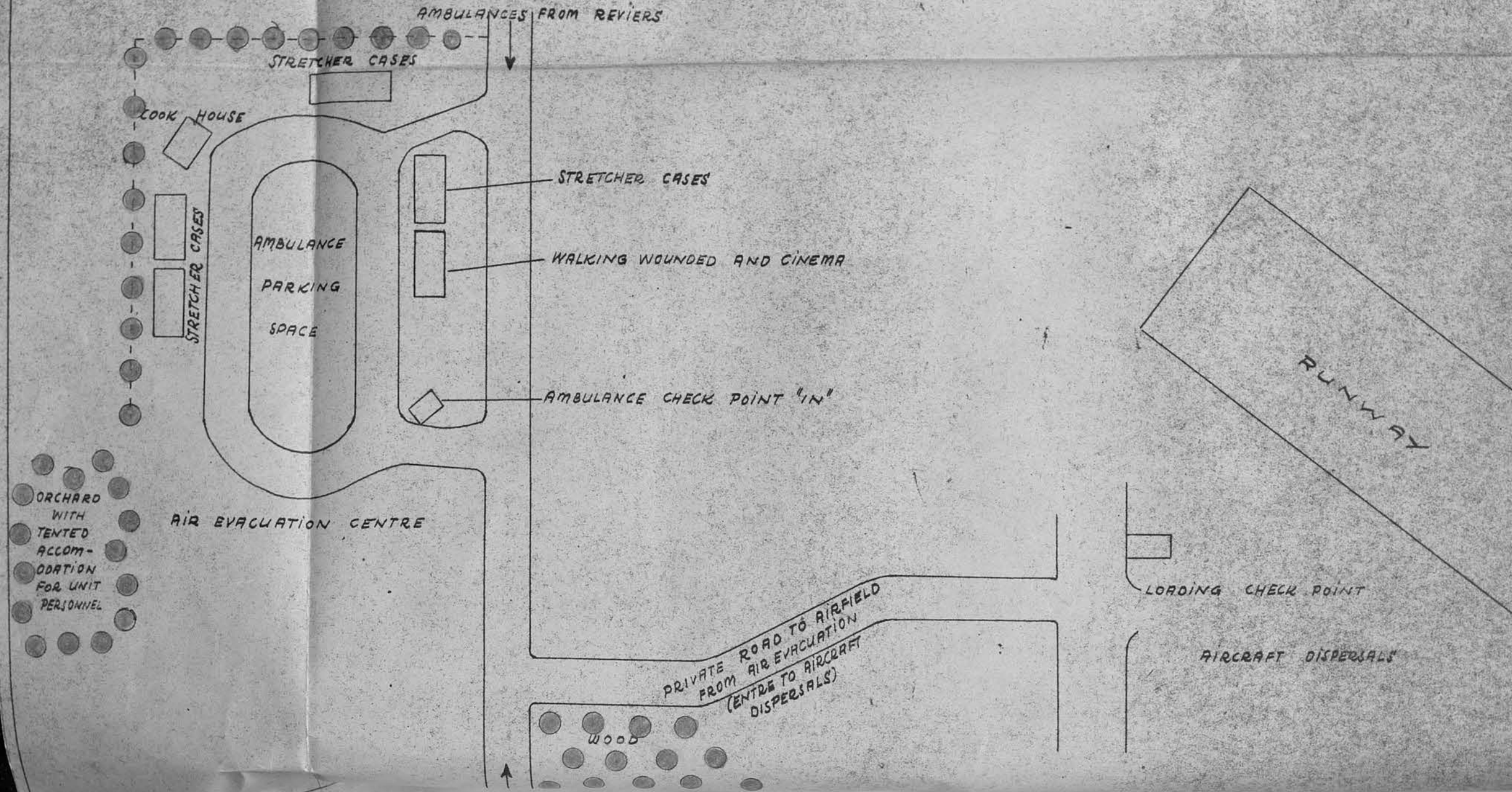


FIG 2

The unit which had been brought in by those aircraft on this particular day was the advance section of a Forward Staging Post. The medical staff were included, with their stores and tentage for sixty casualties. The rear party with the heavy transport arrived almost at the same time. Within a couple of days another complete F.S.P. and the remaining part of the T.A.F. C.A.E.U. arrived. The combined medical staffs of both F.S.P's and the C.A.E.U., six doctors, four nursing sisters, and one hundred men established themselves temporarily on a Fighter airfield, B.8 at Sommervieu near Bayeux, evacuating several hundred casualties. A week later another airfield at B. 14, Banville, had been completed to be used solely as a transport strip, and it was on this airfield that well organised air evacuation commenced by the combined unit already outlined.

The airfield was within three miles of the Casualty Evacuation Post (C.E.P.) at Courselles, the sea evacuation reception centre, and within ten miles of the main hospital area at Bayeux. In addition there were about one thousand Army beds within two miles of the airfield, at Reviers. Tented accommodation for holding up to one hundred and twenty casualties was erected near the airfield, and a road was bull-dozed by the R.E's from the holding section to the aircraft dispersals (Diagrams 3 and 4).

The lay-out and general arrangements on this airfield were eminently satisfactory, and many thousands of casualties were evacuated from it without undue difficulty. Two Medical Air Liaison Officers, one Canadian and one R.A.M.C. were responsible for the arrangement of the delivery of casualties and/

and their alternative disposal if air transport failed. A subsequent useful addition was a surgical team, consisting of a surgeon, anaesthetist, and theatre sister.

The great advantage of this airfield was that if air transport was doubtful because of the weather, or re-allocation of aircraft, the casualties could be diverted to the sea route without loss of time. On one particular day however, 100 plus redundant casualties were transferred to the C.E.P. for evacuation by sea. Next morning they were returned to the airfield because the sea crossing was too rough. It was a relief to know that even the sea evacuation was made impossible by weather conditions sometimes, when air evacuation was possible. Holding accommodation near the airfield also made it possible for casualties to be held overnight so that they could be loaded early in the morning.

The disadvantage of sending casualties back to hospitals did not occur as it had done previously. The administrative turmoil caused by returning casualties to hospitals was great, because between the time of despatch to the airfield, the time spent waiting for an aircraft, and then the return journey, the hospital had as often as not filled up with fresh cases. To find accommodation for those who had been returned, and then to find doctors, was not always easy, and reclassification of the degree of severity of the casualties and operation was often necessary. At the air evacuation centre latterly, a tented theatre was erected and emergency surgery done on cases requiring it which had to be held overnight.

The/

The only two other evacuation units which were involved in the bridgehead were the Canadian C.A.E.U. from 2nd T.A.F. and another F.S.P. medical section. The Canadian unit never joined the large organisation already described, but the other F.S.P. medical section did later. The Canadians did a little evacuation from Normandy, but really only entered the picture in August during the advance through France and Belgium.

The disbandment of the air evacuation units of 2nd T.A.F., and their absorption into an R.A.F. or R.C.A.F. Mobile Field Hospital respectively, occurred at the end of the bridgehead phase. Their new designation was Light Casualty Air Evacuation Section (L.C.A.E.S.).

The units, though not retaining their separate entities, continued to be used for air evacuation purposes, as will be seen later. The step was mainly taken to solve administrative problems. The Casualty Air Evacuation Sections of Mobile Field Hospitals were rarely with their parent units during the rest of the campaign, being detached to Fighter Wings at varying distances from the M.F.H's and working independently on air evacuation duties.

The original plan conceived in anticipation of D-Day, as so often happens, worked out nearly but not quite as expected. It said a great deal for the administrative authorities that so efficient a scheme was evolved in the unanticipated conditions which did arise, not faultless perhaps but excellent nevertheless.

(3). AIR EVACUATION THROUGHOUT THE REMAINDER OF THE CAMPAIGN AND THE INSTITUTION OF THE FORWARD SHUTTLE SERVICE : A BROAD OUTLINE OF THE PERIOD AUGUST 1944 to MAY, 1945.

After eight weeks the bridgehead phase concluded, and the 2nd British Army 'swanned' across the Seine and on to Brussels, with the Canadians following the coastline.

After the British Army moved out of the bridgehead, airfields were captured or constructed for the Fighter Wings just behind the advancing troops. It was often on these airfields that the light casualty air evacuation sections of the R.A.F. Mobile Field Hospitals - Canadian and British - established themselves, and initiated the forward shuttle service as originally planned and outlined in a previous section. In addition, evacuation to the United Kingdom was carried out direct.

The Canadian L.C.A.E.S. covered the forward areas in which the 2nd Army were fighting, and the British one the coastal belt in which the 1st Canadian Army was involved. Moves were frequent as the advance was fast, but both the Canadian and British Units operated in three or four centres each before Eindhoven and Antwerp respectively were reached. The two flights of the Canadian unit worked together and never as two separate flights throughout the campaign. The British unit, however, moved in two flights, leap-frogging each other, and although operating together for short periods, mainly set up as two separate centres. The reason for this was that the character of the fighting originally necessitated evacuation from two centres at once.

The/

The best example of this is as follows:-

The Canadian advance along the coast was held up by Le Havre, Ostend, Calais, Boulogne, and Dunkerque. It was considered necessary to have an Air Evacuation Centre at St.Omer. This town was more or less central for the three latter, where there was a Canadian General Hospital and a mobile Neuro-surgical and Maxillo-facial Unit. Sea evacuation was at Dieppe, which involved a long road journey.

One flight established itself on a captured German airfield outside St. Omer and evacuated casualties direct to England or to the Bayeux base hospital zone. Meantime, the other flight was in Antwerp, evacuating casualties from there. Eventually in September, the Bayeux hospital area began to shut down, and British hospitals opened up in Brussels and its environs, which became the hospital area. The Canadian hospitals were mainly in North Belgium - Bruges, Ooste Dunkerque, etc. The main points from which air evacuation was taking place at this time were Eindhoven, Brussels and Antwerp, with subsidiary small-scale scattered evacuation from places like St. Omer and Diest. The Eindhoven service was partly to the United Kingdom and partly to Brussels, and the Antwerp and Brussels services were direct to the United Kingdom as well as to Bayeux originally.

The air evacuation unit at Brussels was a R.A.F. Mobile Field Hospital, which was temporarily converted for the purpose and worked very well there before resuming its normal duties. Prior to its arrival an Army F.D.S. had been used in a holding capacity, with a F.S.P. medical staff to control the loading. Holding facilities were available in a F.D.S. at/

at Eindhoven, and by a R.A.F. F.S.P. at Antwerp.

To quote from Porritt et al (7):-

"In this phase, air evacuation really came into its "own, and without it the evacuation of casualties back over "the war-scarred congested roads to Normandy would have been "virtually impossible. As it was, the R.A.F., with the able "guidance of Air Commodore Murphy and Group Captain Bruce "Harvey, appeared with a Dakota and almost magical regularity "on what seemed quite impossible fields almost alongside "C.C.S's and Surgical Centres. We, as surgeons, then and on "many subsequent occasions had every reason to be grateful to "the R.A.F. - both its medical staff and its aircrews - for "their wholehearted co-operation".

Air evacuation had proved itself to be a necessity of mobile warfare.

In November, a large unit was formed in Brussels with eight doctors and eight sisters and complete mobile equipment. It was divisible into three flights, H.Q.flight and A and B flights, which were each capable of holding up to 100 casualties per day, with full medical facilities. Each flight was able to handle comfortably 200 casualties in and out per day. Subsequent air evacuation on any large scale was carried out by one of these flights, working often well forward. The H.Q. flight remained at Brussels until the end of the war to receive casualties for the base hospital area, also evacuating others to England.

Where air evacuation was necessary on a smaller scale, the Canadian or British Light Casualty Air Evacuation Sections were utilised, but sometimes found themselves with as many to handle/

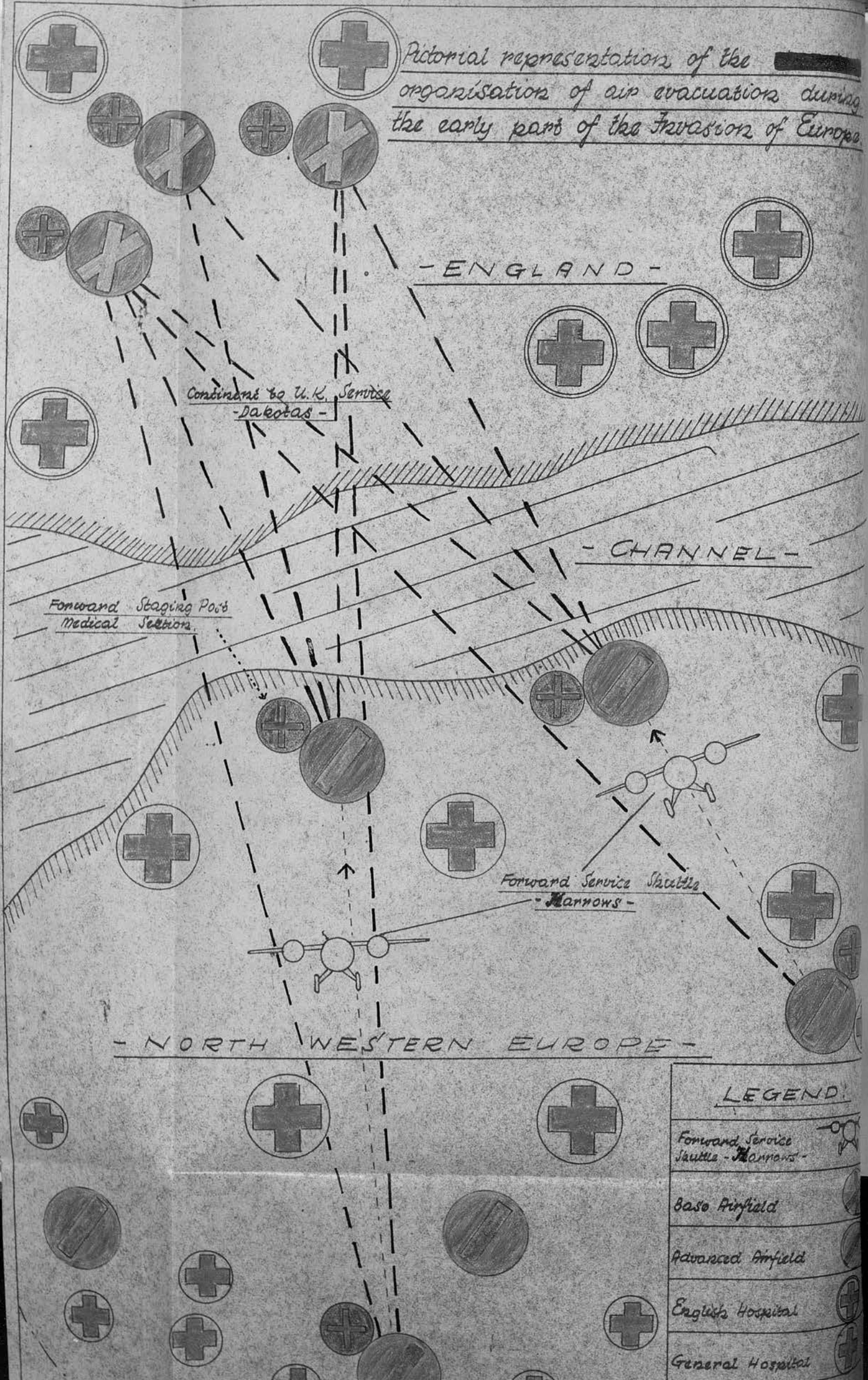
handle as the larger flights of the C.A.E.U. They, however, were nearly always concerned with evacuation out, and had no casualties being shuttled in to them.

In the winter, the Canadians cleared up the coast, leaving only the Czech Independent Armoured Brigade Group encircling the last remaining coastal strongpoint, Dunkirk. Walcheren had been taken in a fierce amphibious operation. Antwerp became the port of the B.L.A., despite the attention it received from the V weapons. Nijmegen was solidly in our hands, and the line was firm up to the Meuse. During the whole of this phase air evacuation had played its part in solving the problem of the disposal of the wounded - a problem of tactical as well as administrative importance.

January the first of 1945 was a day of unhappy memory to those of us who had grown attached to the Sparrow forward shuttle aircraft. The Luftwaffe, staging their last desperate all-out attack on British airfields, destroyed several of them parked on Brussels Airport. They were quickly replaced by Dakotas, but the familiar name ofthe Sparrow flight fortunately persisted.

February 8th saw the Canadians driving through the Siegfried line in filthy weather with shocking road conditions. Casualties were heavy and air evacuation was used to good effect. One specific instance of this was the evacuation of casualties from the Canadian mobile neuro-surgical unit located at this time near s'Hertogenbosch. One daily aircraft to the United Kingdom from a nearby airfield transported on an average 10 head injuries per day during 3 to 4 weeks.

In/


Pictorial representation of the [redacted] organisation of air evacuation during the early part of the Invasion of Europe.
-ENGLAND-
Continent to U.K. Service
-Dakotas-
-CHANNEL-
Forward Staging Post
Medical Section
Forward Service Shuttle
-Marrows-
-NORTH WESTERN EUROPE-
LEGEND.
Forward Service Shuttle -Marrows-
Base Airfield
Advanced Airfield
English Hospital
General Hospital

In March, Goch (B. 100), the first air evacuation centre in Germany, came into action. Following the airborne crossing of the Rhine and the swift advance of our forces across the Westphalian plain, a more forward centre opened on the bomb-scarred airfield at Rheine.

In April, with North Holland still holding out and Arnhem not yet in Allied hands, Nijmegen was being used for fairly large scale evacuation to base at Bruges and direct to England. One medical officer and 20 men there evacuated about 4,000 casualties in that month, 2,200 of them passing through in one week and 450 being the record day.

The final centre at Celle, highly organised in captured airfield buildings, functioned from within a day of the capture of the town until after VE-Day. Evacuation was to base at Brussels, as well as to the United Kingdom. When this day arrived, the whole air evacuation system was working extremely efficiently. The only main difference from the original conception of shuttle evacuation was that air evacuation took place directly to the United Kingdom as well as to base, even from forward airfields. (Diagram 5).

(4). EVACUATION FROM THE CONTINENT AFTER THE CONCLUSION OF HOSTILITIES - MAY 1945 to MAY 1946.

During this period casualty schedules were run as often a week as necessary to evacuate the casualties. This was usually every other day, and the aircraft schedule was laid down in advance. Evacuation was from six centres in Germany and/

and one in Brussels. The signals facilities improved with the diminution of signals traffic. Delays were unusual and evacuation entered a static phase which naturally resulted in good holding accommodation and surgical facilities being available.

Very few casualties, however, really needed evacuation by air, and the service terminated in May, 1946. Since then aircraft have been available for priority casualties, heads, facial-maxillary cases, etc., and the service functions smoothly.

SURGICAL CONSIDERATIONS OF AIR EVACUATION.

Before approaching the surgical aspects of air evacuation, it is wise to pause for a moment to consider briefly the surgery of the campaign in North West Europe.

The following facts extracted from the article "B.L.A. Surgery" by Porritt et al (7) are illuminating.

Surgeons of the B.L.A. achieved remarkable feats during the eleven months of the campaign. Achievements in figures are quoted. Four hundred and six thousand admissions were made to medical wards, of which 258,000 (64%) were treated in the theatre, and 148,000 (36%) transferred to the United Kingdom. More than 50% of the latter travelled by air.

One hundred and eighty-one thousand (45%) of the total admissions were battle casualties, of which 50,000 (28%) received their surgical treatment in the forward areas. Two-thirds of these were serious major wounds. Of the total battle casualties, 39% were evacuated to the United Kingdom, and 61% were treated in B.L.A. Only 6.7% died of wounds.

The figures of the quantity of casualties qualified by the figures of the recovery rate (94%), demonstrating the quality of the surgery, illustrate the skill of the 170 surgeons involved.

Generally speaking, casualties which require active surgical interference benefit more than any other type from rapid and early evacuation to a Surgical Centre. The forward Surgical Centres in B.L.A. usually consisted of 2 C.C.S's, 2 F.S.U's, and 1 F.T.U. Their aim was to provide for as many casualties as possible, the surgical attention which they required. They were not, however, always able to deal operatively with the large number of casualties reaching them, even after screening at a F.D.S. further forward had removed the sick, the minor wounded and the battle exhaustions. Only by careful selection of casualties whose operations could be delayed, and by speedy evacuation of those selected was it possible in such circumstances to do the greatest good to the greatest number. Evacuation by air in the Normandy days provided one satisfactory answer to this problem.

The old established maxim that early definitive surgery is of paramount importance in the elimination of infection and the promotion of successful healing remains unaltered, despite the advance in surgical and medical technique, transfusion, sulpha drugs and penicillin therapy.

There are certain types of surgical casualties which require additional precautions during transit by air, and consideration of these types is essential before generalising

on/

on their suitability or unsuitability for aerial trsnsportation. These specific types will be dealt with individually in the section which follows. Physiological, pathological, pharmacological, and therapeutic consideration of each type will be outlined and basic conclusions reached on their suitability for flight.

INJURIES TO THE NERVOUS SYSTEM.

(1). Cranial Injuries.

By common agreement, injuries to the nervous system are most beneficially treated at a neuro-surgical centre (8), (9), (10), (11).(12)The meticulous care required in the investigation of such cases, the highly specialised surgery involved, and the post-operative and rehabilitatory after-treatment so essential to the attainment of the best results can only be achieved at such a centre. Terian's general fatality rate of 8% in penetrating injuries of the brain during the Russian offensive of the summer and autumn of 1943 illustrates the importance of only trained neuro-surgeons operating on cranial injuries (13). The general concensus of opinion seems to be that operation before the onset of infection is preferable, (14), (15), and that speed in transit to neuro-surgical centres is desirable. The importance of operation within three days or less is stressed by most neuro-surgeons (10), (16).

A comparison of Ascroft's cases with those of Eden (14), (17), reveals the importance of early surgery with/

with regard to the subsequent incidence of post-operative infection.

In the case of the former neuro-surgeon, the patients were received at base at intervals between a few hours to seven days after injury. Three-fifths of the cases had been operated on in forward areas, and only one-quarter received their primary operation at a neuro-surgical unit; 25% of these cases subsequently developed brain abscess.

Sixty-five percent of Eden's cases were operated on within 24 hours of wounding, and his incidence of infection, post-operatively, was 13 out of 102, only one of which 13 was a brain abscess.

In the war in Europe, 2 mobile neuro-surgical units functioned (7), often in the forward areas attached usually to mobile General Hospitals. The 2nd British Army and the 1st Canadian Army each had a mobile unit of this nature. Extra neuro-surgical teams were available at other hospitals by utilising specialists in ordinary hospital appointments. During the peak casualty periods of the major actions, the neuro-surgical potential was often insufficient to cope with all the casualties requiring surgery. It was at such times that air evacuation of treated and untreated cases to head injuries centres in England was of particular assistance. Evacuation by air from areas in which no neuro-surgical unit existed, either to the nearest mobile continental neuro-surgical unit or preferably to England, resulted in considerable saving of life. Aerial transport of the cranial injury applied as beneficially to the cases treated at the mobile neuro-surgical unit as to the selected untreated case which was being transferred to

the/

the United Kingdom by them because of their inability to keep up with the required surgery during a battle. Both types tolerate transport well (9).(12) (17). This has been proved times without number in absolute contradiction to a German allegation that no head injury should be moved within three weeks of primary operation (18). As a generalisation, the closed head can be evacuated without added risk (19).

Both treated and untreated cranial injuries were evacuated in large numbers from North West Europe. The treated cases were usually moved within two to three days of operation, and the untreated cases as soon as their general condition allowed and an aircraft was available. The fact that the majority of these treated cases travelled by air within three days of operation is of significance. Eden (14) states that patients making satisfactory progress can safely be evacuated by air about the second or third day after operation.

The evidence of Gorodetsky (20) suggests that evacuation to base areas, even by air, of operated cases a week after operation may be detrimental to their condition. Jolting of the brain tissues is given as a possible explanation, but I cannot, in the light of my experience, cite evidence in support or condemnation of this statement.

The percentage of all cranial injuries evacuated during general evacuation was 5% to 6% of all casualties, yet during one busy phase of selective air evacuation in February/ March, 1945, the percentage rose to 50%. The interpretation of this fact can only be that the Canadian neuro-surgeons involved/

involved at this time considered evacuation by air to be the most satisfactory method of disposal to base of their cases, whether treated or untreated (21). This confirmed the opinion of British neuro-surgeons with whom I came in contact previously as well as subsequently.

The American authors Gaynor and Gurwitz (22) agree with the observation of British surgeons that patients with head injuries travel well and do so better before than after operation. They opine that unless adequate neuro-surgical facilities are available, operation should not be undertaken, but point out on the other hand that transportation to base may involve dangerous delay. Ascroft (16) is in agreement with them regarding the first part of their opinion and cites over 100 cases which travelled by air.

Air evacuation would seem to be the answer for the rapid evacuation which is deemed advisable in such circumstances. The opinion of one Russian neuro-surgeon (23) at least was that the more quickly a soldier with a head injury is evacuated into a neuro-surgical hospital the better, and that aerial transportation should be used whenever possible. Korniansky, the surgeon in question, suggests that after radical operation, the wounded should be moved to a base hospital on the day of operation if practicable and if their general condition permits, as subsequent development of oedema of the brain makes them unsuitable for transport. This point is mentioned in passing because of its relation to what has previously been written.

The/

The use of the small German Feisler Storch aircraft for evacuation of such casualties is advocated by Leingerber (24), who comments on the unfortunate absence of them on the Russian front. His affirmation that it would be foolish to trephine a skull if an aircraft to a special hospital were available meets with Allied approval.

A dissenting voice, that of Elansky (25), does not support the generally accepted theory that in cranial wounds pre-operative evacuation is preferable to post-operative evacuation. He proceeds to aver that cranial wounds withstand evacuation badly whether before or after operation. Although aerial transport is not specifically mentioned, I have no hesitation in stating that such is not the experience of any medical officer connected with the evacuation of British and Canadian casualties from North West Europe. Although the only casualty which died in the air was a cranial injury on his way from the Continent to England, I personally have seen no evidence to support Elansky's thesis.

Although physiological proof can be obtained that variations occur in the pressure of the cerebo-spinal fluid under reduced oxygen tensions and reduced pressures, those variations are not of sufficient magnitude for important clinical significance to be attached to them. It is safe to state that no significant increase in intra-cranial pressure will arise in casualties who are being evacuated by air if anoxia is avoided (26).

Variations in intra-cranial pressure at decreased atmospheric pressure in a human subject with a large cranial defect/

defect have been recorded by Peterson, Kent and Cone (27). They assume that casualties suffering from head injuries should tolerate air transportation without damage. The speeds and manoeuvrability of the types of aircraft in which casualties were evacuated eliminated the danger of damaging effects to head injuries resulting from the effects of centrifugal force or changes in velocity.

The main pharmacological interest associated with the transit of head injuries centres around sedation. The restlessness of patients with acute head injuries must be effectively controlled without, if possible, causing ill effects, but sedatives must be used with caution. In severe head injuries morphine is found to cause a consistent and considerable rise in the pressure of the cerebro-spinal fluid, usually accompanied by a slowing of respiration and even cyanosis (28). It is felt by many neuro-surgeons that this drug should be avoided except when it is necessary to relieve pain.

The exhibition of intramuscular barbiturates, although causing none of the ill-effects mentioned above, appears to have no appreciable sedative effect. Chloral-bromide is similarly of comparatively little use as a sedative if cranial trauma exists. A combination of codeine grs $1\frac{1}{2}$ intramuscularly and 3 grs of nembutal by mouth procured excellent sedative effects in 85% of a small series of cases quoted by Gurdjian and Webster (29). Sleep occurred within ten minutes of administration of the drugs and only one of the 14 cases showed a rise of any significance in the cerebro-spinal fluid pressure.

Most/

Most cranial injuries travelling from North West Europe had been well sedated before leaving neuro-surgical units, and others were unconscious without being restless. The question of further transit sedation arose in less than 5% of all the cases evacuated. When it did arise, I, rightly or wrongly, did not hesitate to use a quarter grain of morphia parenterally. There were no obvious ill-effects in any of the cases to which morphine was administered during transit, and I know from personal experience that several of the Canadian neuro-surgeons and physicians whom I encountered, had no rooted objection to its use(17)Nembutal alone was used in some cases with somewhat disappointing results, and the difficulty of administering rectal paraldehyde in crowded marquees with minimal facilities precluded the use of what is most probably one of the best drugs in such cases.

Another controversial feature of transit therapeutics in cranio-cerebral injuries arises from the consideration of the fluid intake. As a general rule there would appear to be no necessity for the institution of treatment by hypertonic fluids during transit, especially in closed heads (19). In fact, the reverse would appear to be the case, and it seems important in semicomatose and comatose patients particularly to supply fluid of a nutritive value, such as intravenous glucose saline by slow drip. Dehydration would appear to be unnecessary in the majority of closed cranial injuries (30). The withholding of fluids from a conscious casualty certainly does not appear to be justified.

All/

All casualties air evacuated travelled with their heads towards the direction of flight. Other positions were not tried, but the one mentioned above seems eminently satisfactory. In cranial injuries uncomplicated by other wounds, a neutral position for the head seems to be the most satisfactory one during transit. Eighteen penetrating wounds of the cranium with other complications, such as penetrating chests, were not found to suffer during evacuation from travelling with back rests and their heads raised. The position for the casualty's head is a matter for individual consideration where complicating features exist, and would seem most beneficially solved by the exercise of careful clinical judgment. The head low position, in my opinion, is seldom justified during the aerial transportation of cranio-cerebral injuries. No benefit is derived from the immobilisation of the casualty on the stretcher by straps or sheets during transit (13) unless the weather becomes so rough that it is found necessary.

Therapy by penicillin and sulpha drugs, post-operatively or pre-operatively, was maintained in all penetrating wounds of the head during transit. The decision as to the necessity of such treatment was primarily that of the neuro-surgeon, and air evacuation centres only continued the already initiated therapy. No cases of local penicillin therapy by a tube into the wound were seen by me.

Dressings applied to the patient before leaving the hospital fortunately rarely required attention except in occasional restless patients. No alteration in the incidence

of/

of airsickness was noted in comparison with the other types of cases evacuated. In unconscious patients the danger of bed-sores and burns from hot water bottles must be remembered.

From my own experience of just under 500 cases of head injuries of all types, seen before and during transit by air, I reached the conclusion that, granted reasonable air speeds, and at altitudes of 1,000 to 6,000 feet, the transport by air of cranial injuries does not materially alter the patient's chance of recovery.

SUMMARY OF CRANIAL INJURIES.

(1). Head injuries, treated or untreated, travel very well by air at altitudes up to 6,000 feet.

(2). The risks attended by aerial transportation of such cases are less than by other means because of the gross reduction in transit time and the relative absence of disturbance.

(3). The variations in cerebro-spinal pressure occurring through reduction of atmospheric pressure and oxygen tension are of no clinical significance.

(4). Morphine as an analgesic and sedative can be used as safely during the transit of cranial injuries by air as at ground levels. Paraldehyde rectally is most satisfactory.

(5). Parenteral administration of penicillin should be maintained during transit.

(6). The position of the head should be neutral if not contraindicated by other injuries and towards the direction of flight.

(7). The withholding of fluids does not generally constitute any advantage.

(8). Cranial injuries are no more affected by air-sickness than other types of injury.

(2). SPINAL INJURIES.

Spinal injuries formed less than 1% of the wounded evacuated by air from North West Europe to England. In a general way such injuries fall into two categories, the first without affection of the spinal cord, and the second with paraplegia. On the latter type supra-pubic cystotomy had almost always been carried out. Debenham and Kerr (31) aver that if supra-pubic cystotomy is provided to ensure satisfactory urination, and precautions are taken against the occurrence of bed sores, spines travel well in the normal casualty stream. To this one might add breathing exercises if circumstances permit.

In essence, transit management of spinal cases is identical with their management in hospital. A stretcher is not comfortable for a healthy individual to sleep on, so it is even less so for a soldier who has been wounded. It can even be harmful to his condition if he is unable to move when he feels uncomfortable. Pressure sores and complications may develop to prejudice his general condition. Massive collapse of the lung is more common, it would appear, in battle casualties than in civilian accidents (32). To prevent such complications, precautions must be taken during the transit of spinal cases.

The documents of patients who are unable to move themselves have usually been marked 'Alter position during transit'. This must be carried out regularly. If a case has been overlooked, the air evacuation medical officer should see that the patient's card is marked to this effect. The

nursing/

nursing orderly on the aircraft should be informed of all inert patients and given instructions to alter their position from time to time. In the supervision of loading an aircraft, the medical officer should see that such cases are put in the middle tier of the stretcher racks, as it is easier for the orderly to move the patient if he is in this berth ... Such alterations in position, as well as tending to prevent bed sores, often cause an alteration of breathing and stimulate coughing, which by clearing the respiratory tree of mucus, diminishes the risk of pulmonary complications. Care of pressure points is of paramount importance, either by bandaging over large quantities of wool or by the use of an air ring in the case of the sacrum.

In paraplegics with supra-pubic cystotomy, care must be taken to avoid disturbance of the supra-pubic catheter. When or if a case is encountered before treatment by supra-pubic cystotomy, it is inadvisable to resort to catheterisation unless absolutely unavoidable because of the almost certain introduction of infection (33).

Flying presents a very satisfactory method of transportation for the treated spinal case. It avoids jolting and involves a relatively short transit time. This latter, per se, reduces the liability to bed sores should the patient be overlooked during transit, as can quite easily happen in busy phases. It can be stated without fear of contradiction that spinal injuries with or without cord damage travel well by air and should be given a high priority grading.

SUMMARY OF SPINAL INJURIES.

(1). Spinal injuries with or without paraplegia travel well by air.

(2). The reduction in transit time diminishes the risk of bed sores and massive collapse of the lung.

(3). Precautions must be taken to alter the patient's position at least every two hours and preferably hourly. Particular attention must be paid to the pressure points.

(4). All nursing orderlies in charge of aircraft should be briefed regarding alteration of position and the patients' documents marked 'ALTER POSITION IN TRANSIT'.

(5). Care must be taken during loading of the supra-pubic catheter in paraplegics.

(6). If practicable, breathing exercises should be continued while awaiting transit and during flight.

(3). PERIPHERAL NERVE INJURIES.

A comparison of the organisations for the treatment of such cases in Britain and America can be found in an article by Naffziger (34). He is of the opinion that more specialised care is given to British than to American Forces, despite the fact that Great Britain has proportionately fewer specialists and physicians to their population. This end, he stresses, is accomplished by assembling the patients at fewer centres where senior civilian surgeons can give the assistance of their experience and knowledge to less experienced members of the team. He favours the British practice of locating such centres with or near to medical schools.

Again, one can rightly infer that specialised treatment is best obtained at specialised centres. Obviously, apart from the initial essential surgery, the sooner a patient reaches such a centre the better. The field is no place for time-consuming operations, nor are they practicable in the rush of war surgery.

It is of interest that another article on the subject of peripheral nerve injuries in the European theatre of operations (35) shows that such injuries were transferred from the Continent to 12 neuro-surgical centres in the United Kingdom as promptly as transport facilities permitted. Spurling's contention that certain points in forward management are better standardised is borne out by the figures quoted. His statement that 'Experimental and histopathological evidence indicates that the optimum time for end to end suture of a severed/

severed nerve is between the 3rd and the 9th week after injury, and that repair between the 21st and 28th days is probably productive of the best end results and can be carried out with the least technical difficulties', leads one to wonder if speedy evacuation by air is so essential after all.

The transference of British patients to peripheral nerve centres was always considered of high priority, and I contend that this is the logical outlook. Once forward surgery, by excision of the devitalised tissues, by approximation of the divided ends of the nerves if possible and if not by anchoring the ends to the surrounding soft tissues, by adequate splinting and by delayed primary suture, has been carried out, it is important to transfer the patient as quickly as possible to a peripheral nerve centre.

Experimental work on rabbits shows that the longer the delay between injury and repair, the less likely is there to be full recovery of function, and gives added justification to the high priority grading given to such cases. In addition, the experience of many of the British nerve injury centres was that far too many men were delayed on their way to such centres.

The question of the advocacy of primary or early secondary suture - a highly controversial one (36), (37), (38), (39), must rest with the individual neuro-surgeon. One thing is certain, that the sooner the patient reaches his care, the more likely is the terminal result to be satisfactory for the patient.

After initial surgery in the field, the decision on when and how to complete the treatment is the task of a specialist/

specialist neuro-surgeon. The task of air evacuation is to convey the patient to him quickly, and with minimal danger, and thus to increase the patient's subsequent chance of recovery.

There are no specific difficulties involved in the aerial transportation of such cases.

SUMMARY OF PERIPHERAL NERVE INJURIES.

(1). Early specialised care of the peripheral nerve injury at a specialised centre is advocated.

(2). Standardised primary surgery followed by speedy evacuation for primary or early secondary suture at a peripheral nerve centre would appear advisable.

(3). Evacuation is satisfactorily accomplished by air and involves no specific difficulties.

PLEUROPULMONARY WOUNDS.

Six percent of all cases evacuated by air from North West Europe fell into this category.

It is essential for the Medical Officer in charge of the selection of such cases for aerial evacuation to be conversant with the broad principles governing their surgical treatment. In the early phases of a military operation, such knowledge is of supreme importance because at infrequent intervals, he may be called upon to institute treatment himself during transit.

Primarily, this treatment is aimed at the arrest of haemorrhage, the correction of the profound disturbances in cardio-respiratory physiology and the prevention of infection. Generally speaking, the steps which he may have to take are the aspiration of air and blood from the pleural sac, intercostal nerve block, relief of a tension pneumothorax, the re-application of a pad over the wound of a sucking pneumothorax, oxygen administration and transfusion. To this may be added the haemostasis of intercostal vessels (40).

In the later phases of the campaign, he may expect to receive for evacuation cases which have been treated for several days or weeks in General Hospitals. It is wise for such a medical officer to know the accepted theories on

wounds/

wounds of the lungs and pleura. Consideration of the surgery in such phases is essential, as it bears important relationship to the subsequent probability of the patient becoming suitable for evacuation by air

The general principles involved in the surgery of pleuropulmonary wounds are:-

(1). A sucking wound must be sealed off (41).

(2). Tension pneumothorax, often associated with surgical emphysema, generally caused by a lung wound and frequently without an external wound (42) must be relieved (41). This type of wound is more common in crushing than penetrating injuries.

(3). Paradoxical movement of the chest wall must be stabilised (43), (44).

(4). Progressive haemorrhage into the pleural cavity must be controlled.

(5). Haemothoraces are best treated by early and repeated aspirations, generally without air replacement (42), (45), (46). Minimal air replacement may, however, assist in the complete aspiration of the pleural cavity at certain times (47). In the opinion of most chest surgeons the incidence of infection increases/

increases and pleural thickening is more likely to occur if haemothoraces are not aspirated (47) (48). In passing, it should be noted that the danger of intra-pleural haemorrhage as a result of aspiration seems to have been exaggerated (47), and that the blood in such cases tends to remain fluid probably because of defibrination by the movements of the heart and lungs (41).

(6). The drainage of empyemata when localisation has occurred.

Let us consider the aim of the surgeon and how it affects subsequent evacuation by air.

There are certain physiological considerations in the transport of chest injuries by air which are peculiar to air evacuation alone. Anoxia, the evidence of which becomes manifest in normal individuals at 10 to 15,000 feet (49) is more prone to occur in patients who have suffered pleuropulmonary damage. Alteration in the volume of entrapped air in the pleural cavity due to decreased atmospheric pressure in flight occurs in cases in which pneumothorax or mediastinal emphysema exists. While surgical emphysema rarely involves danger to the patient's life, the same is not true of mediastinal emphysema. It can cause compression of the large/

large veins, and by interfering with the venous return to the heart, reduce cardiac output. This cardio-respiratory embarrassment is more likely to arise during flight at 5,000 feet and above, than at ground level. Whereas a bilateral closed pneumothorax might be fairly well tolerated at ground level if the amount of air in the pleural cavities was small, the same does not apply at 5,000 feet.

Tension pneumothorax, by collapsing the lung, displacing the mediastinum and depressing the diaphragm, creates respiratory and cardiac interference. A point worthy of note here is that the treatment which would relieve the symptoms of altitude sickness in a normal individual will not be effective against the disturbed respiration arising from intrathoracic mechanical changes associated with pleuropulmonary wounds.

The effect of simulated altitude on pneumothoraces has been studied by Todd (50). Five patients with various types of pneumothorax, right and left, mobile and partly fixed mediastinum, with and without adhesions, with and without fluid, and one with a broncho-pleural fistula, were subjected to decompression. The study elicited certain important information. One case with a complete pneumothorax showed gross mediastinal shift radiologically at a simulated altitude of 9,000 feet. Pain was usually the limiting factor which/

which preventedpatients being taken to greater altitudes. The introduction of a needle before flight was advocated.

Peterson et al (51), investigated two cases, both tuberculous, by decompressing them at 1,000 feet per minute with the provision of excess oxygen throughout the investigation. One case had a 20% pneumothorax and the other a 50% pneumothorax. The former reached a pressure equivalent to 20,000 feet without showing any marked loss in oxygen saturation or mediastinal shift. The latter patient began coughing and became distressed at between 10 and 15,000 feet. His oxygen saturation was impaired at 15,000 feet. Important inferences to be drawn from this investigation are that a patient with pneumothorax should be carefully examined before evacuation by air and relief of the pneumothorax by aspiration considered, that oxygen should be given from ground level, and that cough should be allayed by sedatives. The most important conclusion is that patients with limited pneumothoraces need not be denied the benefits of aerial evacuation. The amount of fixation by adhesions and the extent of lung fibrosis in Peterson's cases must have affected to some extent their liability to develop symptoms. While it does not necessarily follow that/

follow that the observations of Peterson can be applied to battle casualties, the inclusion of this investigation in the section on pleuropulmonary wounds seems justified.

One of the most important considerations in the treatment of penetrating chest injuries involving the pleura is early pulmonary expansion. The steps taken surgically prior to evacuation are all in the right direction as far as subsequent evacuation by air is concerned. The closure of a sucking chest, the evacuation of air or blood from the pleural sac, and the stabilisation of paradoxical movement are all beneficial to the patient from the distant viewpoint of subsequent evacuation by air, as well as from the immediate surgical aspect. As the normal surgical treatment of a tension pneumothorax is decompression, of a sucking pneumothorax conversion to a closed simple one, and of a haemothorax aspiration, any doubts which might exist regarding the disposal of such cases to base by air subsequently can be dispelled.

The thesis of entrapped air propounded by Goldman (52), tends to be irrelevant unless casualties are being flown before surgical treatment. In such circumstances, wholehearted agreement is given to his statement that a closed/

closed tension pneumothorax must be relieved before evacuation, and a sucking wound converted to a closed one. I have seen no evidence to support or contradict his affirmation that surgical emphysema may need incision as a result of altitude.

With regard to increased altitude and the cardio-vascular changes associated with it in thoracic injuries, I would go further than Goldman and say that no significant changes are noted under 4,000 feet. His suggested upper limit is 3,000 feet. Four thousand feet is the figure recommended by Todd (50), who qualifies his statement that no patient with a wound pneumothorax should fly at over this height by adding 'unless as much air as possible is removed from the pleural sac at ground level'.

While on the subject of the altitude of 4,000 feet, it is noteworthy that one pleuropulmonary wound which was reported to have died during evacuation in the South Pacific did so after flying for two hours at this height. Flaherty and his co-workers (53) assert that death was due to intrathoracic haemorrhage. It is to be remembered in this association that a man can bleed to death into his own pleural cavity without undue embarrassment of respiration from diminution of pulmonary volume (41).

Before/

Before proceeding to the transit pharmacology, one controversial question remains to be raised. Is it better for a pleuropulmonary wound to fly uncomfortably at 4,000 feet in rough weather or to fly comfortably at 6,000 feet? My personal opinion is that there is no doubt that less danger is caused to a patient with a chest wound from flying at 6,000 feet than is caused by his suffering from airsickness, retching, and vomiting at 4,000 feet. This opinion has stood the test of trial successfully, and I do not hesitate to commend it more particularly when oxygen can be administered if there is the least sign of dyspnoea due to the increase in altitude. Crews of aircraft must be guided on suitable heights at which to fly by the medical officer in charge of the evacuation.

Attention will now be given to the consideration of several therapeutic and pharmacological features of the transit of pleuropulmonary wounds.

The relief of pain which effects an improvement in the respiratory movements and often encourages the patient to cough more freely (40) can be affected safely by the exhibition of morphine in doses up to a $\frac{1}{4}$ grain I.M.I. or if necessary 1/6th grain intravenously (44). Large doses of morphine, however, abolish the cough reflex and may cause depression/

depression of respiration (41), (43). Pain associated with intercostal nerve injury is relieved by morphine, and this drug is not contraindicated in controlling pain and shock provided it is used in an intelligent way.

Another satisfactory method of relieving pain is by intercostal nerve block. One percent procaine is injected at the rib angles of the painful area and at two segments above and below it. This, by diminishing the pain, generally leads to the coughing up of excessive broncho-pulmonary secretions, which is desirable.

Barbiturates for sedation are contraindicated where low oxygen and high carbon dioxide concentrations exist in the blood (41). Atropine should be withheld except pre-operatively, as it increases the viscosity of the bronchial secretions (41) and makes the expulsion of them by coughing more difficult. Coramine is an effective respiratory stimulant, and was available in all aircraft flying casualties.

Blood or plasma transfusion must be used with caution, because over-liberal introduction of intravenous fluid can precipitate pulmonary oedema(44).

Oxygen is best administered to anoxic cases at 7 litres per minute, using a mask preferably of the B.L.B. type. Oxygen could not be given to all pneumothoraces from/

from ground level as was suggested by Peterson et al (51). It had to be reserved for cases requiring it therapeutically and not prophylactically. In the early Normandy days, 8% of casualties required oxygen in transit, while in the later stages in France, Belgium, Holland and Germany, this figure fell to 0.7% . This may be taken to illustrate the essential difference in the transport of partly treated and fully treated pleuropulmonary casualties by air.

Patients with chest injuries need not be forbidden to smoke during transit unless smoking induces uncontrollable bouts of coughing. Breathing exercises should be continued whenever circumstances permit.

Penicillin parenterally should be exhibited during transit where its administration has already been commenced. If aspiration is necessary in an air evacuation centre, penicillin should be introduced into the pleural sac when the aspiration is completed. A dosage of 30,000 units in 20 c.c's. of saline is suggested. Of the cases seen during evacuation, only 8% had empyemata and only in very occasional cases were drainage tubes seen. This was probably due to the fact that most cases were evacuated

to/

to the United Kingdom before the infection had become sufficiently localised for drainage to be instituted. There is no doubt that penicillin intra-pleurally and systemically as an adjunct to thorough surgery and early aspiration had a favourable influence on the occurrence of empyema.

Thoraco-centesis should be performed before evacuation if the pleural cavity is suspected to contain more than 500 c.c's of fluid, or if dyspnoea, cardiac or mediastinal displacement exists in conjunction with fluid (44). Aspiration can be carried out until 1,000 c.c's of fluid are removed or until the patient complains of tightness in the chest. The truth of the observation by Ross (54) that it is as reprehensible not to aspirate the pleural effusion of a dyspnoeic patient as to fail to split a plaster is generally accepted.

The treatment of tension pneumothorax and sucking pneumothorax has been mentioned previously, and further discussion here is unnecessary.

The position of the patient on the stretcher and in the aircraft is important. Pleuropulmonary wounds should travel sitting up and supported by a back rest. Such stretcher cases are best carried on the floor of the aircraft and not in the racks.

The evacuation of pleuropulmonary wounds is usually carried out about the 7th day after wounding. It is felt that evacuation from the third day onwards, depending on the patient's general condition, can be safely effected. Agreement on this statement can be found in German and Russian literature. V. Brandis (55) believes the optimum time for evacuation to be between the 2nd and 7th days, while Demudov (56) thinks that chest injuries should be held at the place of operation for 3 to 5 days before evacuation. Too early evacuation of patients with severe haemothorax or pneumothorax is also deprecated by Wildegans and Bansi (57).

The decision as to when a case is fit for evacuation should rest primarily with a physician who can be guided on the surgical advisability by a surgical confrère.

Schmoele and his associates (58) consider that casualties with pleuropulmonary injuries can and have been safely and advantageously transported by air to rear Naval hospitals in the South Pacific despite the danger from diminished partial pressure of oxygen at altitudes.

There is no doubt that the same findings appertained to evacuation by air from North West Europe. It is/

is felt that the surgery already performed in operated cases allowed them to travel well. Such is not the case in the early phases of a military operation, as in Normandy, where several cases received little more than essential first aid treatment before earlier evacuation. The amount of oxygen necessary during transit appears to be a guide to the adequacy of surgical treatment.

SUMMARY.

(1). Six percent of all cases evacuated from North West Europe were pleuropulmonary wounds. Eight percent of these had been diagnosed as having empyemata. In the early stages of the liberation of Europe, 8% required oxygen therapy in transit. This figure fell to 0.7% as the campaign progressed.

(2). Medical officers in charge of air evacuation centres should be conversant with the essentials of pleuro-pulmonary wound treatment, so that they may be able to carry out any required treatment before emplaning. This is more important in the early stages of a military operation than subsequently.

(3). The surgical steps taken to treat chest wounds improve their prospects of successful evacuation by air.

(4). Pleuropulmonary wounds are best flown below 4,000 feet, but/

ABDOMINAL INJURIES.

Occasional penetrating abdominal injuries within a short time of wounding found their way to air evacuation centres in the early days of the Normandy bridgehead.

This was unplanned, but cannot be condemned in the stress of that period;with the difficulties in triage and the amount of operative surgery to be done, it would have been a miracle if it had not happened by accident a few times. None of these cases died in the aircraft, but unfortunately I have been unable to follow up their future treatment. The reason why they were loaded on to aircraft was that with the prevailing conditions, congested rutted roads, casualty clearing stations overflowing, and surgeons operating for more than 12 hours at a stretch, the risk to the patient was no greater than it would have been in returning him by road ambulance to the nearest surgical unit. Flying at 1,000 to 2,000 feet, for 50 minutes, he could be at an airfield in England where surgery could be performed should it be impossible to move him to the nearest hospital 10 miles away without increasing the danger to his life.

In subsequent phases of the war in North West Europe, abdominal wounds were rarely sent from hospitals for evacuation until at least 10 and usually 14 days after operation (59), (60), (61). Even so, such cases travel rather/

rather worse than other types of casualty at the same or earlier post-operative time (59), (62). They travel as well by air at this time as they do by sea, and should be transported by air (61).

The slow climb from ground level to 1,000 to 6,000 feet and flight between those levels cannot cause danger to the scar by distension of the bowel from intestinal gas expansion. Air sickness would reasonably be expected to be more dangerous, and attempts were always made to exclude abdominal injuries from aircraft loads being flown in rough weather.

The generally lowered physical state of the patient who is recovering from operation for a penetrating abdominal injury seems to create an apprehension to travel in any form, and although none of them refused evacuation by air, they, more frequently than any other type of casualty, required reassurance on the subject of aircraft and flying.

Therapeutically, the supervision or initiation of transfusion of blood or plasma, preferably the former, the withholding of fluids by mouth and the judicious use of morphine (63) are the only steps which an Air Evacuation Officer can take when pre-operative penetrating abdominal injuries accidentally find their way to him. The nursing of the operated case in transit centres round the attention

of/

of the colostomy, if present, and the supply of a suitable dietary if possible. The working of colostomies did not seem to be affected by flight at 1,000 to 6,000 feet. The percentage of colostomies carried was high in abdominal wounds evacuated by air, conforming with the standard British practice. Breathing exercises should be continued during transit as they diminish the liability to pulmonary complications (64).

Death, attributed to shock following abdominal distension during flight in a case of peritonitis is reported by Flaherty et al (53) from the South Pacific. They assert that it is dangerous to fly abdominal cases until several days after operation when abdominal distension has subsided.

Air is no exception to the basic rule governing the movement of abdominal injuries. The transport by air of penetrating abdominal injuries before the 14th post-operative day is deprecated unless of absolute necessity. Even after such time it is inadvisable to fly such cases in rough weather.

It would appear that the life of a penetrating belly undergoing resuscitation, in transit to a surgical centre, is not any more endangered by aerial transport than by other means, provided the time from wounding to operation/

operation does not exceed ten hours at the outside.

If a comparison could be made between two similar penetrating abdominal wounds, one flying with resuscitation pre-operatively, and still being operated on within eight hours of wounding, and another flying for the same length of time on any day up to the 7th day after operation, I am certain the prognosis would be more favourable in the case of the former.

Regarding evacuation, the inference that the use of local anaesthesia in abdominal wounds as described by Pschenichnikov (65) allowed evacuation immediately after operation must be accepted with reserve until more conclusive proof is forthcoming.

Thoraco-abdominal wounds, of which a relatively small percentage survive, travel as well as the average penetrating wounds of the gut. The rules governing the evacuation of abdominal injuries appertain to such cases.

SUMMARY OF ABDOMINAL INJURIES.

(1). Penetrating wounds of the abdomen should not travel by air before the 14th post-operative day.

(2). Rough weather should be avoided even after the 14th day.

(3). Although cases should not be moved pre-operatively, there is nothing to indicate that they suffer more from transit by air than by other means if resuscitation is provided.

(4)/

(4). Reassurance is important before flight.

(5). Thoraco-abdominal wounds travel as well as other abdominal injuries. The abdominal and not the thoracic, are the features to be considered when choosing the time of evacuation.

LARGE FLESH WOUNDS.

Such wounds when encountered during transit fall into two classes - those which are complicated by bony injury and those which are not. Both varieties benefit as much as any other type of casualty from rapid air evacuation.

In a busy period, when forward units may only have time to carry out the initial treatment of such injuries, speedy evacuation is important. If a patient cannot be held under observation for three or four days until delayed primary suture can be performed, the risk of anaerobic infection occurring in the wound during slow evacuation to base cannot be disregarded. Particularly is this the case in the Low Countries and France (66).

Doubtless the risk has been greatly diminished by the introduction of penicillin into the armamentarium of the surgeon, but it remains a very real one nevertheless. Slow transit, over a period of 24 to 36 hours, may render the observation of such cases difficult and operation virtually impossible. A transit period of short duration, as is provided by air evacuation, would appear to have a definite advantage in this respect. Especially is this the case when damage has occurred to a blood vessel supplying a large group of muscles, as well as to the muscles themselves/

themselves. Parenteral penicillin is relatively ineffective, as the drug never reaches the damaged tissues. The risk of infective myositis in such cases is greatly increased. Air evacuation in those circumstances would appear to be indicated because of the shortness of time spent in transit. This in itself diminishes the risk of subsequent loss of a limb or death by toxaemia.

The first casualty that I saw in Normandy had such a wound which was the seat of anaerobic infection. This experience led me to have great respect for large flesh wounds and to accord them the high priority grading which I consider they deserved, if they were being evacuated before delayed primary suture. After delayed suture the priority of such cases is low because healing is usually fast and satisfactory, assisted by pre- and post-operative penicillin.

The danger of secondary haemorrhage in untreated flesh wounds must never be forgotten while they are in transit. It is apt to be overlooked until it is encountered, and if special watch is not kept for it, resuscitative measures may be delayed until they are too late to be effective. It is important to remember that it is the task of the medical officer evacuating surgically untreated wounds/

wounds by air to contribute as much as possible toward the preparation of the casualty for surgery. He must be conversant with and observe the fundamental principles involved in the treatment of wound shock.

In the initial phase of a combined operation, when for tactical reasons the evacuation of virtually untreated casualties may be essential, early and speedy evacuation contributes towards better terminal surgical results. Despite penicillin, travelling transfusions and sulpha drugs, the most important anti-bacterial agent is early evacuation as it brings the casualty to the operating table (67). Air evacuation played a large part as an anti-bacterial agent in the bridgehead days.

Flesh wounds involving bone had all been immobilised before evacuation, even in Normandy. All unpadded casts had been split before the patient started transit, and there were very few justifiable complaints from the patients regarding the tightness of their plasters. Any such complaints must be taken seriously however, as there are several complications associated with a tight plaster. The main ones are the development of pressure sores, and nerve palsies. The detection of gas gangrene under such a plaster is also less likely (68). Critical observation of constitutional signs and/

and symptoms should prevent this dangerous oversight from happening. These complications are obviously more likely to arise when careful watch is not continually maintained on the plasters. A predisposing factor toward their occurrence is a lengthy transit period, which is avoided by the use of aircraft.

Similarly, a road journey along extended lines of evacuation, which may be very uncomfortable for a patient with a compound fracture, especially if a good plaster technique is not adhered to (69), can be avoided by air transport.

SUMMARY OF LARGE FLESH WOUNDS.

(1). Incompletely treated cases should be given a high priority during evacuation, especially from North West Europe, because of the danger of gas infection. This is more than ever necessary if a blood vessel supplying the wounded area has been damaged.

(2). Secondary haemorrhage may occur and should be kept in mind.

(3). Flesh wounds after delayed primary suture are of low priority for air evacuation.

(4). In untreated cases rapid and early air evacuation can be classed as an anti-bacterial agent.

(5). Complaints about the tightness of plasters should be investigated carefully.

(6)/

(6). Air evacuation provides the most comfortable method of transport for immobilised compound fractures, and for simple fractures also.

BURNS.

Cases suffering from burns travel well by air, provided the normal procedure regarding the relief of shock and pain is complied with.

FACIO-MAXILLARY INJURIES.

The advisability of treating such injuries at specialised centres qualifies them for Priority One air evacuation. The difficulties of feeding them orally may be overcome by using a Ryle's tube. Careful attention must be paid to tracheotomy tubes when present. Involvement of the sinuses did not appear to contra-indicate air transport.

EYE INJURIES.

Penetrating injuries with or without lodged foreign bodies were afforded priority transportation. Their transit presented no difficulties.

EAR INJURIES.

Flight below 6,000 feet did not cause any apparent ill-effects on patients suffering from blast injuries of the membrana tympani. Many of these had other injuries which made their air evacuation a matter of necessity. The slight discomfort, of which occasional patients complained, may have been due to impatency of the Eustachian tubes.

SURGICAL THERAPEUTICS, WITH SPECIAL REFERENCE TO PENICILLIN.

The dressing of all wounds during transit, unless indicated for any specific reason, was avoided because of the very great danger of introducing infection. After the early Normandy phase it was completely unnecessary except for very occasional dressings which had become unfastened in one way or another.

Regarding the surgical aspect of the campaign in North West Europe, there is no divergence of opinion on one thing. In comparison with the wounds of previous campaigns, the wounds of this campaign showed an absence of serious sepsis and a generally reduced incidence of all wound infections. It is accepted that penicillin therapy is the main reason, although not necessarily the only one.

To quote from 'Penicillin Therapy and Control in 21 Army Group (66):- 'All the dangerous pathogens found in war wounds are penicillin sensitive, and if one can get the penicillin into contact with them and maintain it there in an adequate concentration for a sufficient period of time, these organisms should be inhibited or destroyed. Prevention is better than cure, so it is obviously desirable to exploit penicillin /

penicillin prophylactically at the earliest practicable stage and in the most effective manner possible. The basis of the penicillin policy in 21 Army Group since D-Day has been prophylaxis. Arrangements were made to use penicillin both parenterally and locally at the most forward surgical levels so that casualties should receive it as soon as possible after wounding. Arrangements were also made ensuring that penicillin, once started, should be continued no matter how or where the patient went, until such time as he had been evacuated or until a surgeon decided that the treatment could be terminated'.

There can be no doubt that the incidence and severity of wound infections have diminished because of the generous use of penicillin.(66).

In the early days of the bridgehead, the initial air evacuation units were not always able to obtain sufficient penicillin, nor were they always able to administer it during transit owing to the rush and the necessity of speedy loading of casualties.

When one large unit took over all of the evacuation by air at B. 14 in Normandy, it became possible to administer it routinely. Penicillin, from this time to the end of the war in Europe, was administered parenterally in 20/40,000 unit doses in all cases in which its use had not been terminated by/

by the evacuating surgeon. If there was a delay of a few hours prior to evacuation, the dosage was kept up, and later in the campaign, with lengthening flights, double booster doses were given if the casualty was not likely to arrive in the United Kingdom before his next injection was due.

The penicillin used by the smaller air evacuation flights was drawn daily from the nearest Army Hospital, but the larger flights carried stocks of their own.

Local penicillin was rarely used during transit. Where irrigation tubes had been installed and its continuation advised, it was given according to the instructions of the evacuating surgeon.

In addition to parenteral penicillin, many cases received oral sulpha drugs. In the light of the since accumulated evidence (66), there would appear to have been no necessity to risk the toxic effects of this group of drugs by continuing their administration.

THE CONSIDERATION OF SOME MEDICAL ASPECTS OF AIR EVACUATION.

The percentage of medical cases carried by air from North West Europe to the United Kingdom was roughly 15% of the total evacuated. This estimate is based on the analysis of 5,000 cases evacuated to England at different stages of the campaign. The percentage of medical patients transported to the Continental base areas by shuttle aircraft was double the above figure.

It will be noted that casualties were rarely flown at altitudes of over 6,000 feet, and all observations refer to flight under such height.

This section is divided into:-

(1). The transport by air of patients with diseases of -

(i). The cardio-vascular system.

(ii). The respiratory system.

(iii). The alimentary system.

(iv). The central nervous system.

(v). The haemopoietic system.

(vi). The ear, nose and throat.

(vii). An infectious nature.

(2). Air sickness.

(3). The relation of psychology and psychiatry to air evacuation.

(4). Therapeutics in relation to altitudes.

(1). THE TRANSPORT BY AIR OF PATIENTS WITH DISEASES OF

(i). THE CARDIO-VASCULAR SYSTEM.

Patients suffering from valvular diseases of the heart, both compensated and uncompensated, were found to be transportable by air without risk. There would appear to be little danger of anoxia occurring at heights below 6,000 feet if the patient is fit to be moved from hospital for evacuation. Where a reasonable cardiac reserve exists there is no danger of anoxia at such heights.

Angina pectoris would not seem to be affected by flight at low altitudes, although I suspect that anginal pain might easily occur in flight in an individual of an emotional nature, or in the event of stress, say due to the failure of one engine in flight. Although I encountered no case of coronary thrombosis, I can see no reason why flying either early or late cases of this disease should be contraindicated if routine therapeutic measures have been instituted and the patient's general condition permits.

Oxygen should always be carried and used if any tendency to dyspnoea is noted in cardiac patients.

(ii). THE RESPIRATORY SYSTEM.

The effects of altitude on pneumo-, haemo-, and haemo-pneumo-thorax have already been considered in the surgical section.

The/

The conclusions drawn there apply equally to cases of artificial pneumo-thorax, spontaneous pneumothorax, and pleurisy with effusion. Flight at low altitudes would not appear to precipitate the occurrence of spontaneous pneumo-thorax in normal individuals. It is generally considered inadvisable to fly patients who have had a recent haemoptysis, but no evidence to prove this can be cited from the evacuation of such casualties from North West Europe.

All types of tuberculous patients were transported by air, particularly after VE-Day, when ex-prisoners of war were being flown home. No ill-effects resulting from flight were noted by the medical officers receiving such casualties, and no untoward effects occurred during the air passage. Three cases of miliary tuberculosis which I evacuated did not appear distressed during their evacuation, although one was just dyspnoeic at ground level and required oxygen in transit. None of the evacuated tuberculous cases had been treated by artificial pneumo-thorax. It is suggested that if tuberculous patients are being flown, this procedure should be delayed until after the flight or at the most a 20-25% pneumothorax not exceeded.

In/

In pleuro-pulmonary medicine, the suitability for flight obviously depends mainly on the patient's general condition, the presence or absence of mediastinal displacement or cavitation, the amount of functioning lung tissues, and whether oxygen is obtainable during flight.

The availability of oxygen on the aircraft is stressed during the transportation by air of all patients with respiratory diseases. It can be used beneficially as a prophylactic measure from ground level in the most serious respiratory complaints where dyspnoea might arise in transit. Oxygen, to be of optimum assistance, should be given before dyspnoea arises.

Tuberculous patients travelling among other patients should be loaded in the lowest berth and should wear a mask.

(iii). ALIMENTARY SYSTEM.

Few specific difficulties are associated with the aerial transportation of patients with diseases of this system. At the usual altitude at which evacuation took place, any expansion of the gas in the intestine which did occur was insufficient to give rise to symptoms.

When patients with peptic ulcers are being air-evacuated it is advisable for each one to be supplied with a packet of sandwiches and a bottle of milk by the evacuating hospital.

Patients/

Patients with ulcers who have had haematemeses should not be transported unless their haemoglobin level is over 50%. No gastric accidents, such as perforation or haematemeses, occurred during transit. It would have been of interest to observe the effect of flight on a perforation, because I can see no reason why such a case should not be flown to the nearest surgeon. I contend that the transport by air of an early perforation from say Tiree to Glasgow within six hours of its occurrence would not materially alter the chance of survival.

Flight during rough weather should be avoided in patients with peptic ulceration because of the risk of air sickness and possible haematemeses.

(iv). THE CENTRAL NERVOUS SYSTEM.

In the surgical section of cranial wounds it has already been noted that if anoxia is avoided no significant increase in intracranial pressure occurs during casualty evacuation by air (p.38). It is known that hyperventilation alkalosis or anoxia can precipitate attacks of petit mal in suspectible individuals. The liability to loss of consciousness and syncopal reactions at a simulated altitude of 18,000 feet, without oxygen for 15 minutes, has been studied by Baxter et al (70). Their investigation indicated/

indicated that many of those developing syncopal reactions had central nervous system disorders which tend to epilepsy. Anoxia is only likely to arise during air evacuation below 6,000 feet in the presence of cardiac, respiratory or haemopoietic disease. It can be avoided by the intelligent use of oxygen in the two former and by blood transfusion in the latter and is no contra-indication to the evacuation of the majority of patients. Provided adequate therapeutic measures are taken to prevent anoxia, no rise in the cerebrospinal fluid pressure should occur, nor should there be any danger of syncope in any patient whether he has a tendency to epilepsy or not. The war in Europe proved that air-evacuation of patients with diseases of the central nervous system can be effected safely. None of the patients evacuated developed syncopal attacks or unconsciousness and symptomatically there did not appear to be any gross variation in intracranial pressure, judged by alteration in the severity of their headache.

Two patients whom I accompanied to England on four hour flights were suffering from meningitis. One was of meningococcal origin and the other tuberculous, but on a purely clinical assessment neither showed any detrimental effects attributable to transport by air. Neither case had had other than routine treatment in preparation for his aerial journey. Another patient who travelled without deterioration in his general condition/

condition was suffering from poliomyelitis with diaphragmatic paresis. During transit he was continuously supplied with oxygen and his breathing assisted by artificial respiration. He reached a Drinker machine in the United Kingdom in good condition, having exhibited no syncopal signs during transit despite the difficulty of providing him with oxygen.

Although epileptics were not routinely flown from the Continent, I can find no physiological or medical reason for their exclusion from aircraft, except that they might have had a convulsion in the air. There is no reason to assume that such a convulsion would have been any more dangerous to the patients at 6,000 feet than at ground level, but the restraint of such a patient might have been impossible by the nursing orderly of the aircraft. The exclusion of epileptics from an aircraft is therefore a justifiable and necessary safety precaution.

(v) HAEMOPOIETIC SYSTEM.

Advanced anaemia, no matter what its cause, can produce anoxia. The main problem arising from the evacuation of such cases is the avoidance of oxygen lack. The administration of oxygen will not materially assist in preventing anoxia in haemopoietic disease. On the day before, or on the day of evacuation patients whose haemoglobin level has

fallen/

fallen below 50% should be given whole blood by transfusion in preparation for the journey by air. The quantity given should be sufficient to raise the haemoglobin to at least 50% and preferably higher. One patient whom I accompanied by air on a four hour journey to the United Kingdom was suffering from aplastic anaemia. His haemoglobin was raised to 70% on the day before evacuation, by whole blood transfusion. No ill effects were observed during flight. It must be remembered that anoxia may arise in such cases without the warning sign of cyanosis (71).

(vi). EAR, NOSE AND THROAT.

A simple explanation of the changes occurring in the ear during ascent and descent to altitudes is essential before giving the contraindications to aerial travel in otological cases.

It should be remembered that air can pass easily from the middle ear to the throat along the Eustachian tube. Passage of air in the reverse direction is not so easily accomplished. Swallowing tends to open the Eustachian tube and facilitate air entry from the throat to the middle ear. During

ascent/

ascent the decrease in atmospheric pressure causes the air in the middle ear to expand and the pressure becomes equalised by air passing along the Eustachian tube into the throat. In the normal individual no damage to the drum can occur during ascent because air can always escape. During descent, however, the pressure in the middle ear becomes lowered and air has to pass in through the Eustachian tube from the throat if equalisation of pressure is to occur. If equalisation is not effected thus, the difference in pressure rises and the drum bulges inward causing pain. Swallowing or holding the nose and blowing assists in opening the Eustachian tube and equalising the pressure. If these steps are not taken the drum may rupture. Rapid descent may also stretch the drum without rupturing it and giving rise to earache of several hours or several days duration.

The definite possibility of rupturing or stretching the drum during descent exists in everyone who flies with a blocked Eustachian tube.

The presence of a perforation and chronic otitis media does not preclude aerial transportation because drainage and air entry are effected through the perforation. Cases of acute otitis media with an unperforated membrana tympani should not be flown, as the ear drum is likely to perforate during ascent, or if it does not//

not, pus is liable to infiltrate into the mastoid cells.

Sinusitis and blockage of the sinusoidal ducts give rise to pain which is not usually severe, during ascent and descent because of pressure alteration within the sinus. From my experience of air evacuation on the Continent it does not contra-indicate the transport of such cases by air unless very acute.

(vii). INFECTIOUS DISEASES.

Infectious diseases patients are obviously unsuitable for transport by air unless they are carried alone in an aircraft. The difficulty of fumigating the aircraft afterwards makes their transport so troublesome that it is not worth while. The necessity for it fortunately arises very seldom anyhow. The only cases of an infectious nature normally carried from Europe were tuberculous. They were always given a gauze mask to wear, and they were loaded on the floor of the aircraft where they were least likely to disseminate Koch's bacilli over other casualties.

The only other infectious cases carried were mainly an occasional pneumonia, infective hepatitis and malaria. The danger of the spread of such diseases during transit is too remote to be worth considering.

(2) /

(2). AIR SICKNESS.

In reasonably good weather it was unusual for patients to be airsick. In somewhat bumpy or really rough weather it was common to find several airsick patients in each aircraft load. The first of such patients to be airsick was generally one who tended to be seasick or railsick and in whom one consequently expected it. With the others this was not always the case, and there seemed to be a strong pyschogenic background for their airsickness. I have no doubt that airsickness often has an 'infectious' origin. When one patient vomits, others seem to follow his example for little reason at all.

The overall incidence of airsickness was less than 1%. In view of this figure and the doubts regarding the efficiency of preventative therapy, no routine treatment was given prophylactically. Several Army experiments on seasickness suggested the use of hyoscine orally in doses of .5 - 1.2 mgs (72). One can assume that it may also diminish the liability to airsickness, but I do not think its routine administration to battle casualties can be considered justified.

To withhold a light meal before evacuation on a rough day appears to be unreasonable as it focuses the patient's attention on the possibility of his being airsick and pyschologically renders it more probable. If a patient is going to be airsick/

airsick anyhow, it is less uncomfortable to have a full than an empty stomach.

(3). THE RELATION OF PSYCHOLOGY AND PSYCHIATRY TO AIR EVACUATION.

The existence of undoubted aerial supremacy over the Continent and United Kingdom and the justifiable confidence in British and Dominion air and ground crews, accounted for the fact that no Allied casualty in 20,000 of which I had personal experience refused to be flown. As a tribute to Goebbels' propaganda it may be stated that two German prisoners of war in Normandy refused because they were in doubt of our air superiority and feared attack by the Luftwaffe. They travelled by sea.

Reassurance on the subject of flight and the absence of risk was made easy by the fact that the stock answer to any question on this subject was "We haven't lost or injured a casualty yet". To be able to keep repeating this sentence from the beginning of a major campaign until its end speaks highly of the efficiency of air and ground crews alike. The presence of female nursing orderlies on the aircraft even as early as a week after D-day had an excellent pyschological effect on the casualties carried. These orderlies and the crews who flew them were never casual when patients were being carried, and/

and in an intangible and indescribable fashion seemed to inspire the confidence of the army casualties who formed the bulk of those carried.

Perhaps this ability to inspire confidence was the legacy of the Battle of Britain, the thousand bomber raids and the airborne landings of D-day but a 'Je ne sais quoi' existed which played its part in preventing the aerial journey from being clouded for the patient by apprehension or fear.

Sedation of medical or surgical casualties was very rarely necessary. Pyschiatric patients, the majority of them suffering from battle exhaustion, did however require sedation. Half an hour spent recovering 20 patients with battle exhaustion from under vehicles, from ditches, slit trenches and hedges during a night air raid in Normandy convinced me of the insufficiency of a three grain dose of nembutal for the sedation of such cases. Subsequently $4\frac{1}{2}$ grain and sometimes 6 grain doses were used and a good night's rest assured for such patients awaiting aircraft overnight in an air evacuation centre. The 20 cases mentioned above seemed perfectly willing to fly next morning and behaved well while airborne. Although the transportation of this type of patient is not without risk because of the danger of their attempting to interfere with/

with the crew of the aircraft or attempting to step out of it, I think there is a tendency for those dangers to be exaggerated. Battle exhaustion is rarely accompanied by suicidal tendencies. Indeed patients suffering from this illness have often broken down mentally because of their desire to remove themselves from dangerous surroundings. Having agreed to flight, I feel that it is unlikely that they should wish to commit suicide, but a sudden panic caused by their considering the possibility of the aircraft crashing, makes them a danger to themselves and others. For this reason such casualties were not routinely carried after the breakout from the bridgehead. Subsequently, towards VE-Day neuro-psychiatric patients were again afforded the benefits of air evacuation if certified fit for air travel by a neuropsychiatrist.

The transport of schizophrenics, manic depressives or patients with suicidal tendencies is contraindicated.

It must be remembered that the majority of the casualties carried from North West Europe were in the 20 - 30 years age group. Whether people in older age groups, say 40-50 or 50-60, are so well suited psychologically for flight is a controversial point. Personally I do not think that the present generation in these age groups would be, although with the increasing use of aircraft and/

and better blind flying and safety measures, the same will not necessarily apply to the 40-50 age group in 20 years time.

(4). THERAPEUTICS IN RELATION TO ALTITUDES.

I have observed no clinical contraindications to the use of penicillin during flight. Peterson et al reached the conclusion experimentally that morphine and sulphathiazol could be safely given in transit to patients who were undergoing evacuation by air at altitudes below 10,000 feet (73), (74). Clinical corroboration is provided from the results of the air evacuation of casualties from North West Europe. It is of interest to note that although in the early air evacuation from Normandy morphine had to be administered to 5% of the cases, it was less frequently necessary (1 to 2%) in transit during the later stages of the campaign. This,no doubt,was due to the fact that many of the patients evacuated from Normandy had not been so completely treated surgically.

There is no difficulty in maintaining fluid infusion or transfusion during flight, provided a cannula is introduced into the vein and tied in. Needles are unsatisfactory if the weather is at all rough. Alterations in pressure due to flight do not materially affect the rate of flow and are easily controllable.

THE/

THE APPLICATION OF AIR EVACUATION TO THE CONDITIONS OF PEACE.

In the Services there is no doubt that the evacuation of casualties by air will continue to be maintained in peace. The benefits of air evacuation, although mainly felt by the patients, can also assist in solving some of the problems of the medical administrator. As a method of evacuation from small punitive expeditions against insurgents, it should be extremely useful (75). Its use as a means of quickly transferring patients with injuries to special systems, e.g., to head injuries, facio maxillary or chest centres cannot be too strongly recommended.

In Great Britain the scope of the evacuation by aircraft is limited because of the limited distances. Evacuation of patients from islands off the Scottish coast to the mainland should be possible and advantageous.

In the Dominions, however, aircraft can and will be used to transport patients from the backwoods to the hospital wards of the large cities. The evacuating medical practitioner should remember that there are no absolute contraindications to the transport of any case by air in emergency (71). A knowledge of resuscitation and the basic principles of the effects of flight and altitude on the body, coupled with and guided by clinical experience and common sense, should enable any doctor to decide whether it is justifiable to transport

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a patient by air or not.

The most satisfactory method of making aircraft available for such patients would be on a 'bespoke' basis.

A State controlled and financed scheme would obviously be desirable. Amphibious aircraft strategically disposed on airfields in proximity to large hospitals would be despatched to pick up patients on the request of the doctor treating the patient. Those aircraft would carry oxygen and medical equipment including blood and plasma, and a trained nurse would be responsible for the patient's well-being in transit.

SUMMARY.

INTRODUCTION.

EVACUATION OF CASUALTIES IN WAR.

Granted aerial supremacy, evacuation of casualties by air is the method of choice in all evacuation involving distances of over 100 miles, especially if a sea crossing is necessary.

ADVANTAGES OF AIR TRANSPORT.

The main advantage is the shortness of time during which the casualty is in transit.

DISADVANTAGES OF AIR TRANSPORT.

That air evacuation can rarely be used as the sole channel for disposal of casualties to base is disadvantageous.

A/

A BRIEF ELABORATION OF THE ADVANTAGES AND DISADVANTAGES OF EVACUATION BY AIR.

The advantages far outweigh the disadvantages.

HISTORY OF AIR EVACUATION BEFORE THE WAR AND DURING THE YEARS 1939 - 1946.

Prewar air evacuation was sporadic and on a small scale. Evacuation by air of casualties in the early years of World War II was handicapped by shortage of suitable aircraft. In the later months of 1942 the numbers of patients evacuated in the Middle East rose steadily, and in 1943, 28,000 were air evacuated in this theatre. In this year, air evacuation units formed in England, were ready to take a part in the invasion of Europe.

Eighty-two thousand casualties were transported from North Western Europe to England without the loss by accident of one casualty in transit. This figure, which represents 60% of all casualties transferred to the United Kingdom, does not include those transported by the forward shuttle service (42,000). In the Far East the percentage almost reached 100 in forward areas.

The chances of survival were naturally increased for tens of thousands of casualties.

THE/

THE DEVELOPMENT OF AIR EVACUATION IN ENGLAND AND NORTH WESTERN EUROPE FROM SEPTR., 1943, TO MAY, 1946.

(1). The formation of Casualty Air Evacuation Units in England and their functions, taking into consideration the policy of the period Septr., 1943, to June, 1944.

An outline of the development of air evacuation and the training of personnel for duties with air evacuation units is given. Dakota aircraft are well suited for the transport of casualties.

(2). Air evacuation from Normandy - June, 1944 - Augt., 1944.

The importance of self supporting mobile units in the initial stages of a campaign is stressed. A suitable layout for an air evacuation centre is pictorially represented (Diags. 3 and 4);

(3). Air Evacuation throughout the remainder of the campaign and the Forward Shuttle Service, August, 1944 - May, 1945.

Mobility remains the keynote of success. A forward shuttle service relieves the strain on the lines of communication, and should be instituted as soon as tactical conditions permit.

(4). Air Evacuation from the Continent after the conclusion of hostilities - May, 1945 - May, 1946.

The use of a scheduled service to meet evacuation requirements is satisfactory, although aircraft when required are better secured on a 'bespoke' basis.

SURGICAL/

SURGICAL CONSIDERATIONS OF AIR EVACUATION.

GENERAL CONSIDERATIONS.

The importance of early definitive surgery remains unchanged. In periods of great activity, air evacuation can assist in achieving this end by transporting the casualty to the surgeons more quickly than in other ways. Injuries to special systems should be treated at specialised centres.

INJURIES TO THE NERVOUS SYSTEM.

(1). CRANIAL INJURIES.

The risks attended by aerial transportation of such cases are less than by other means because of the diminution in transit time and the relative absence of disturbance. Head injuries travel well by air whether treated or untreated.

(2). SPINAL INJURIES.

The alteration in position of such cases during transit by air is important. The shortness of transit time diminishes the risk of bed sores and pulmonary complications.

(3). PERIPHERAL NERVE INJURIES.

Standardised primary surgery followed by speedy evacuation for suture at a specialised centre is recommended. Air evacuation prevents delay in transferring the patient to such a centre and involves no specific difficulties.

PLEUROPULMONARY/

PLEUROPULMONARY WOUNDS.

Provided oxygen is available in transit and the evacuating medical officer is conversant with the basic principles of plemopulmonary wound treatment, air evacuation of patients with this type of wound can be safely effected, either during the initial or later stages of any campaign. The amount of oxygen used during transit would appear to give an indication of the adequacy of surgical treatment.

ABDOMINAL INJURIES.

Penetrating abdominal wounds should not travel by air before the fourteenth post operative day. Rough weather should be avoided even after this time. The preoperative transport of penetrating abdominal injuries is not advised, although there are no indications that aerial transport is more detrimental to their condition than other means, providedthe journey is of short duration and resuscitation is provided. The fitness of patients with thoraco abdominal wounds for transportation is governed by the abdominal and not the thoracic features.

LARGE FLESH WOUNDS.

During the initial phase of a campaign large flesh wounds, complicated or uncomplicated by bony injury, should have a high priority for evacuation by air. More especially is this the case from a theatre of operations where the danger of anaerobic infection is known to exist.

BURNS/

BURNS.

Such cases travel well by air if the effects of pain and shock are effectively combatted.

FACIOMAXILLARY INJURIES.

This type of casualty merits priority for evacuation by air. Feeding, if difficult, can be satisfactorily effected by the use of a Ryle's tube.

EYE INJURIES.

Evacuation by air presents no difficulties.

EAR INJURIES.

Diagnosed rupture of the membrana tympani by blast is not a contraindication to air evacuation.

Injuries to the special senses which are outwith the compass of a general surgeon should be evacuated by air to a specialised surgeon if facilities for their treatment do not exist on the spot.

SURGICAL THERAPEUTICS WITH SPECIAL REFERENCE TO PENICILLIN.

Penicillin has reduced the incidence of infection in war wounds and its exhibition during transit and flight should be continued if it is considered necessary. There would appear to be no need for treatment with sulpha drugs at the same time.

THE CONSIDERATION OF SOME MEDICAL ASPECTS OF AIR EVACUATION.

The percentage of medical cases evacuated from North Western Europe to the United Kingdom was roughly 15%. All observations refer to flight under 6,000 feet.

THE TRANSPORT BY AIR OF PATIENTS WITH DISEASES OF:-

(1). THE CARDIO VASCULAR SYSTEM.

Patients with valvular disease of the heart are air-transportable. Anoxia rarely occurs below 6,000 feet, and never if a reasonable cardiac reserve exists. Oxygen should always be carried and used if any tendency to dyspnoea is noted in cardiac cases.

(2). THE RESPIRATORY SYSTEM.

Flight does not appear to precipitate the occurrence of spontaneous pneumothorax in normal individuals. Tuberculous casualties can be carried safely by air provided a pneumothorax of over 25% does not exist. Oxygen must be available on aircraft transporting patients with pleuropulmonary disease.

(3). THE ALIMENTARY SYSTEM.

Patients with peptic ulcers who have had haematemeses should not be flown unless their haemoglobin is over the 50% level. Flight during rough weather of patients with peptic ulceration should be avoided because of the risk of air sickness and possible perforation or haematemesis.

(4)/

(4). THE CENTRAL NERVOUS SYSTEM.

The exclusion of epileptics from the benefits of aerial transport is only justified as a safety measure.

(5). THE HAEMOPOEITIC SYSTEM.

Patients with haemoglobin levels of below 50% should not be air transported until their haemoglobin is raised by transfusion. Anoxia may occur in very anaemic patients without the warning sign of cyanosis and is not relieved by the administration of oxygen.

(6). THE EAR, NOSE AND THROAT.

Cases of sinusitis and otitis media are unsuited for aerial transport only during the acute stages.

(7). INFECTIOUS DISEASES.

In the infectious stage of any illness a patient must travel alone in the aircraft. Fumigation of aircraft is very difficult. Tuberculous patients should wear a gauze mask and be loaded on the floor of the aircraft where they are less likely to disseminate Koch's bacilli over other passengers. If these precautions are taken, actively tuberculous patients may be flown.

AIR SICKNESS.

Air sickness would appear to have a strong psychogenic background. A low incidence - less than 1% is noted. No prophylactic medicinal or dietetic treatment is considered necessary.

THE RELATION OF PSYCHOLOGY AND PSYCHIATRY TO AIR EVACUATION.

The patients must have confidence in the aircraft and aircrews. This can largely be achieved by past results and by reputation. The employment of female nursing orderlies on aircraft increases the feeling of confidence and is strongly advocated. Cases of battle exhaustion require considerable sedation, but littledanger exists in their transport by air. Schizophrenics, manic depressives and those with suicidal tendencies should be excluded from aircraft loads.

THERAPEUTICS IN RELATION TO ALTITUDES.

Penicillin, morphine and sulpha-drugs do not appear to have detrimental effects on the body at altitudes below 6,000 feet. Plasma infusions or transfusions are relatively unaffected by flight at such altitudes.

THE APPLICATION OF AIR EVACUATION TO THE CONDITIONS OF PEACE.

Evacuation of Service casualties during peace will be beneficial to the patients as well as of assistance to the medical administrator. Aircraft can most satisfactorily be obtained on a 'bespoke' basis. The benefits of using light aircraft or helicopters to transport casualties to hospital from punitive expeditions in difficult country are obvious.

Evacuation of civilian casualties could be most satisfactorily/

satisfactorily effected in the Dominions and possibly from the islands around the British coastline.

There are no absolute contraindications to the transport by air of any case, in emergency. Common sense alone can enable any doctor to decide whether or not a casualty is air transportable.

CONCLUSION.

The circumstances which prevailed during the war of 1939 to 1945 may never exist again. Passing to the realm of conjecture it is not fancy to assume that the subject matter of this thesis may soon become of historical interest only.

It can be said of the past that the evacuation of casualties by air contributed in no small measure to the efficiency of the medical arrangements of the three fighting services. It secured a place in modern warfare from which it can only be ousted by a better and quicker means of casualty transportation, when this is discovered. The recent advances in helicopters, the developments in jet propulsion and aircraft design, and the probable use of atomic energy as a motive force for aircraft propulsion lead me to believe that such a method will soon be devised. The medical problems associated with such advances will no doubt be great though not insuperable.

The/

The observations and conclusions contained in this thesis may contribute in some small way to the solution of such problems, and if not they may serve as a reminder of the part which air evacuation of casualties played in the Second World War.

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