

## Aeromedical Evacuation

**Erich Roedig, Brig.Gen ret. MD, CFS**

Berliner Straße 52  
53819 Neunkirchen  
Germany

[recce52@aol.com](mailto:recce52@aol.com)

### *Abstract:*

*NATO Strategy changed with the end of the cold war. In this context, medical support during operations must correspond to the mobility and flexibility of the units to be supported. Aeromedical Evacuation (AE) is usually the fastest and in many cases the only life-saving mode of transportation in the Evacuation Chain. In the forward area AE rotary wing platforms have long been the normal. Fixed wing platforms are used for Intra- (Tactical) and Inter-(Strategic) AE in correspondence to STANAG 3204. Its importance is driven by factors, which include adequate trauma care, the distance from home country to the mission area, the dispersed nature of NATO forces in the Area of Operations, the lack of useful host nation support, austere environment and the lethality of modern weapons. The factors above have triggered an increase in the movement of less stable casualties over long distances.*

*Therefore sufficient and qualified AE capacities as well as trained and experienced medical personnel at and between all levels of medical care are a prerequisite for the fast, competent and, if indicated, intensively medically monitored transportation of critically sick or wounded patients to treatment facilities that provide definitive and final specific casualty and medical care (rehabilitation).*

*Today, air rescue and AE constitute an indispensable integral part of modern medical support.*

### **1. HISTORY**

The history of aeromedical evacuation (AE) is short and closely associated with the beginning of manned aviation. Its origins are credited to the Dutch medical officer De Mooy who, in about 1910, was the first to conceptualize the air transport of wounded patients and to describe the interaction of road, rail and air transport. Air transport of wounded patients in hot-air balloons, frequently mentioned in the context of the Franco-Prussian War, however, must be considered a military anecdote, as there is no historical evidence for it.

First documented evidence for the routine employment of aircraft for the transport of wounded patients exists for the First World War when France established an aircraft ambulance organization. During the Spanish Civil War (1936 – 1938), the air transport of wounded patients to Germany was conducted on a larger scale. By time of the Second World War, organized air transport of wounded patients had been established in the military. The US-Army Air Corps for instance had evacuated 1.25 million patients by aircraft and with limited in-flight care (flight nurses) by 1945. While approximately 4% of the wounded were dead by the time they arrived for the first emergency surgical treatment during the Second World War, this percentage could be reduced to 1% during the Vietnam War when the introduction of helicopters for air rescue missions was brought to bear on a large scale.

## Aeromedical Evacuation

---

The operational need for a qualified AE system can also be inferred from the example of operation Desert Storm where approximately 30,000 allied soldiers were evacuated from the operational theatre for reasons of health. During the IFOR/SFOR mission, the German Air Force conducted 211 evacuation flights from 01 January 1996 to 31 December 1998.

From 2003 to August 2006 the US Air Force has moved a total of 37,000 patients through Europe from Southwest Asia via airevac. Approximately 6800 of those were battle injuries of which up to 500 were treated by CCATT's. In flight critical care has enabled movement of trauma patients over long distances to reach definitive care within hours of injury.

## 2. OPERATIONAL REQUIREMENTS

NATO strategy changed with the end of the Cold War. The integration of crisis reaction forces in the new military strategy of NATO, that is determined by the basic characteristics "concentration of forces", "flexibility", "global mobility" and "multinationality", requires an efficient medical service. In addition to the conduct of national sovereign tasks, it must have the capability for international cooperation in the sense of interoperability (standardization).

In this context, the military requirement is that the mobility and flexibility of medical support during operations must correspond to the mobility and flexibility of the units to be supported. Thus the transport of wounded and sick patients receives a new status as far as quality and quantity are concerned. The responsiveness of the medical service and especially of an efficient AE system must be adjusted to the responsiveness of NATO Reaction Forces and to that of the forces employed for rescue and evacuation operations and must be available for ad-hoc operations within the scope of disaster and emergency relief if required. An efficient air transport system for wounded patients is definitely required operationally for sustained operations to establish sustainability and to cope with periods of peak requirements.



Fig. 1: Transall C 160

NATO STANAG 2228 (23) attaches importance to medical support as close as possible to national peacetime standards. In addition, the technical guideline of the Surgeon General of the Bundeswehr dated 27 September 1995 set forth the following maxim for the medical support of Bundeswehr servicemen abroad (quote):

*“The maxim of task accomplishment in the medical service is that the soldiers in the event of an illness, accident or injury shall receive medical care, that, as far as the result is concerned, corresponds to the medical standard in Germany.”*

This must certainly also apply to the medical evacuation chain. At NATO level, AE and medical air transport in the forward area are established in STANAG 3204 and STANAG 2087. This impressively underlines the status of qualified aeromedical evacuation within NATO (22).

In addition to the AE requirements based on operational reasons, the „Evacuation Policy“ determined by the military command increases the extent of AE. This policy establishes the maximum period of a soldier’s unfitness for service in the operational theater. If, according to medical prognosis, this period will be exceeded, the soldier is to be evacuated as soon as this is possible and can be justified from a medical point of view (1,2,3,4).

### **3. MEDICAL REQUIREMENTS**

#### **3.1 General/Aeromedical Aspects**

Aeromedical evacuation is usually the fastest and in many cases the only live saving mode of transportation. It is conducted in the knowledge that the immediate clinical care for acute conditions will decisively improve the patient’s prognosis on mortality, invalidity and the development of posttraumatic stress conditions. In view of this, the modular medical facilities in the operational theater are indispensable assets of the qualitative and scalable medical support that must be complemented at all levels by aircraft that are properly equipped and assigned to air transportation forces. Upon conduct of appropriately thorough preparations there should be no absolute contra-indication against an AE, given sufficient personnel and material. Qualified aeromedical evacuation of wounded and sick patients can only be conducted as efficiently as possible if the medico-technical requirements are met and the accompanying medical personnel are appropriately trained. Basic knowledge of aeronautics, aviation medicine and flight physiology must be demonstrated in addition to the clinico-technical expertise in emergency and intensive medicine.

The accompanying medical personnel should belong to the aircrew and be subject to the appropriate airworthiness criteria. The immense logistic and financial effort required can only be justified if the in-flight medical care meets the standard of the personal medical care provided at home.

In this context, however, the physiological factors that influence air transportation are of particular aeromedical importance.

#### **Physiological Factors Affecting Air Transportation**

- Reduced Atmospheric Pressure
- Decreased Oxygen Tension
- Dehydration
- Motion Sickness
- Fatigue and Inactivity
- Psycho-physiological Effects

## Aeromedical Evacuation

---

### 3.2 Flight Surgeons in the AE-chain

Physicians and in particular the flight surgeons play an essential role in aeromedical evacuation (AE). Incomplete or insufficient preparation for AE can result in patient discomfort, and in a worst case scenario, potentially serious or insurmountable in-flight medical problems (13).

To carry out a successful AE mission, physicians are responsible for processes.

- AE rescuing, including determination of appropriate classification, procedure and special medical requirements
- Validation (i.e. patients medical condition, location of appropriate medical treatment, facilities, available AE assets, AE policy)
- Medical preparation to minimize risk of medical decompensation and patient discomfort in the AE environment
- Clearance, i.e. confirmation through flight surgeons that AE rescuing and medical preparation for all conditions is done and that the patient's condition has had significantly worsened.

Physicians' role in the AE-system has broadened and become progressively more crucial with the shift from moving stabilized patients (rather than stabile) must ensure that airways are assured, fractures stabilized, all haemorrhage is controlled including damage control surgery measures and fluid resuscitation has successfully begun.

### 3.3 Types of AE

- FORWARD AE

Normally helicopter and the V/STOL Aircraft will be used for forward medical evacuation. Patients will be frequently untreated inadequately stabilized prior to area. Forward aeromedical evacuation describes the phase of evacuation, which provides airlift for patients between points within the battlefield to the initial point of treatment and to subsequent points of treatment within the combat zone.

- TACTICAL AE (Intra-theatre aeromedical evacuation)

Describes the phase of evacuation, which provides airlift for patients from the combat zone to points outside the combat zone and between points within the communication zone.

- STRATEGIC AE (Inter-theatre aeromedical evacuation)

Describes the phase of evacuation, which provides airlift for patients from overseas areas or from theatres of activity operations, to the home base, to other NATO countries or to temporary safe area.

## 4. MEDICAL AIR TRANSPORT IN THE FORWARD AREA

### 4.1 The Challenge

In all imaginable situations going along with medical emergencies, time is the crucial determinant, which can make the difference between life and death.

In medicine it is a well-proved axiom that one can influence and improve the prognosis of casualties once qualified medical support has been initiated (18). To shorten the interval for wounded soldiers or patients

in lack of adequate therapy, emergency medicine sought the advantages of helicopters to provide medical care at the earliest possible time and to guarantee a very effective and rapid response to life-threatening situations (22).

Air rescue medicine has developed extensively over the past 60 years and is still changing. The increasing engineering progress in aviation and the current state-of-the-art medical equipment opened the way for helicopters and fixed wing aircraft to perform as modern, highly mobile intensive care centres (14).

Therefore, professional expertise and procedures are mandatory to understand and carry out critical care interventions in the Air Medical Transport (AMT) environment.

Experienced and well-trained personnel and the optimized preparation of the patient before take-off ensure effective medical care in flight even over long distances (10, 24).

## 4.2 Medical Principles

Aeromedical rescue/evacuation is defined as the movement of casualties by air transportation under medical supervision to and between medical treatment facilities.

The special tasks for Air Rescue / Ambulance Helicopters are as follows:

- fast and direct transport of medical specialists and equipment to the disaster site
- direct and careful transport of emergency patients to more distant specialized hospitals with maximum individual care
- carrying out urgent secondary AMT of intensive care patients (IC patients) between hospitals
- SAR missions (ICAO, IMO)
- Combat Search And Rescue (CSAR)
- The decision to evacuate a patient by air necessitates experienced aeromedical judgement after adequate examination and best-available therapy; the thorough assessment of the medical benefits for the patient versus the hazards, which might occur in the air.
- On the other hand, there are no absolute medical contra-indications for AMT. Accepting only stable patients is not a golden rule, because stabilization on the emergency site is not always practicable (stabilized versus stable patients).

## 4.3 Primary Air Medical Transport (air rescue)

The rapid and direct air transport of medical specialists and equipment to the disaster site and the direct and careful medically monitored transport of stabilized patients to further specialized medical care can be defined as primary AMT.

## Aeromedical Evacuation

The medical indication for rapid AMT often results in using different types of trauma scores (NACA Index; Glasgow Coma Scale; Trauma Score (TS); Injury Severity Score (ISS); APACHE-II; RAPS, TISS). However, the indication to move emergency patients by air is given in polytraumatic patients with:

- severe fractures
- spine injuries (paraplegia)
- thorax trauma (instability, respiratory insufficiency)
- open injuries of different body regions
- skull fractures (cranio-cerebral trauma - CCT)
- extreme loss of blood

In the field of Internal Medicine, the following diagnosis can be considered for primary AMT:

- MCI (cardiogenic shock; cardiac rhythm disturbances)
- pulmonary embolism
- acute cardiac insufficiency
- respiratory insufficiency
- bleedings
- comas (metabolism)
- intoxications

The early intubation in the preclinical polytrauma management is an essential measure for patient stabilisation.

**Table 1: Indication for early intubation in preclinical polytrauma management (25)**

traumatic resuscitation and persistent hypovolemic (hemorrhagic) shock unconsciousness with severe CCT acute obstruction of the upper airways sustained respiratory insufficiency polytraumatic patients (danger of MOF) thorax trauma trauma combination pattern of injury polytraumatic score (NACA, Glasgow)
---

### 4.4 Secondary Air Medical Transport (Inter-Facility Transfer)

Secondary AMT may become necessary in the case of serious illness and/or injuries after stabilization, but also if complications develop that cannot be dealt with in hospitals and which require further treatment by specialized medical centers (7).

Those helicopters in use carry medical equipment for complete invasive and non-invasive monitoring, artificial respiration using all possible ventilation patterns, and facilities for electric therapy and pharmacotherapy (5,8).

Due to field related specialization of medical centers in our nations, the aeromedical Inter-Facility Transfer of critically ill and/or injured patients over long distances has gained more and more importance (27).

#### 4.5 Search and Rescue

Challenges and difficulties concerning the primary AMT management of emergency patients in mountainous or maritime locations are often caused by delayed and insufficient alert, exposing the casualties to the cold and extremely hazardous environment.

Only by helicopter, effective preclinical treatment is available. Patient rescue is more than often carried out by hoist manoeuvres in adverse weather operations and under extreme psycho-physiological workload (8; 15; 20; 21).

International organizations (ICAO, IMO etc.) have been formed to standardize SAR operations requiring international cooperation. The member nations provide internationally agreed comprehensive standards, practices and procedures for SAR within their territory over land and sea. Helicopters are effective tools because of their low speed and hovering capability. They are usually equipped with a hoisting device for rescue and delivery operations.

#### 4.6 Combat Search and Rescue (CSAR)

Rescuing isolated personnel from hostile territory has always been a dangerous task

The clinical doctrines of traditional Combat Search and Rescue (CSAR) are currently under review.

Old paradigms about combat rescue operations only take place behind enemy lines have been overtaken by the requirement to recover isolated personnel on asymmetric battlefield, which have no fixed frontlines. A lot of effort is currently under way to harmonize doctrines, procedures and equipment interoperability. Personnel recovery does not replace CSAR. It is different and it is an aggregation of a lot of things: it brings together CSAR, non-combatant arrested recovery, prisoner-of-war/missing-in-action activity, development and evaluation of new technology.

Situational superiority is a key requirement for successful combat rescue operations. (17)

### 5. Safety Aspects

Air medical rotor-wing aircraft have an alarming history of accidents, which result in morbidity and mortality all over the world.

In 1986, 14 emergency medical service helicopter crashes occurred, destroying or substantially damaging 9 % of the US air medical helicopter fleet (11).

During air rescue missions, 10 German military SAR helicopters crashed between 1989 and 1995, causing eight fatalities and 18 injured (16).

It is an undoubted fact that flying of air rescue helicopters includes a series of possible stressors, both physical and psycho mental, and requires a lot of skills and experience from the total aircrew team performance (9).

On the other hand, safety issues in aeromedevac equipment get more and more into focus. Electromagnetic interference (EMI) and electromagnetic susceptibility (EMS) of medical equipment used on board must be evaluated to avoid effects on engine control, communications and navigation of the aircraft and on the mode of operation of the equipment itself. Other safety issues to take into account for specialized aeromedical equipment include susceptibility to G- forces, rapid deceleration and acceleration.

## **Aeromedical Evacuation**

---

The same is true for the influence of human factors, vibrations, altitude and electric safety on the mode of operation of the medical instruments. All of those have an effect on the safety of the patient, the flight platform and crew.

Therefore, the establishment of internationally agreed definitions of both technical and medical standards, with particular consideration being given to the concept of „safety first“, is mandatory (8).

### **6. C 4 ISR**

The medical C 4 ISR rescue organization must be capable of planning, executing, controlling, supporting and auditing the full spectrum of aeromedical support functions.

It must be capable of providing and ensuring a seamless system of control of treatment, evacuation and transfer of information, including patient documentation throughout the evacuation chain to definitive treatment. This improves productivity and guarantees better management of operation's cost and quality of care.

Telemedicine, once the technology is fully developed, will have an enormous impact on helicopter AMT operations by strengthening the AMT crew's future ability to provide the right level of rescue and care to a patient. Helicopters can thus be diverted to more deserving or urgent cases, making operations more cost effective and reducing asset redundancy (26) from the initial point of injury or sickness.

## **7. TACTICAL/STRATEGIC AEROMEDICAL EVACUATION**

### **7.1 General Aspects:**

This is the domain of relieving aeromedical evacuation by means of which patients submitted to medical (intensive medical) monitoring are transported to receiving medical facilities outside the operational theater in the event of deployments or when local capacities are exceeded.

Especially in the tactical and strategic area, the operational concept described above results in an extended operational spectrum for AE, which impressively demonstrates the necessity of in-flight intensive medical monitoring.

- Within the scope of the preparation of operations and during the build-up of medical facilities in the operational theatre, an efficient AE system for the qualified medical support of the soldiers deployed is to be established before the modular medical facilities are put into operation.
- Military missions to be conducted without a sufficient preparation period for the medical service require a highly responsive medical support system that also meets emergency/intensive medical requirements. Well-trained specialist personnel and medical equipment are transported to the operational theatre immediately and ensure a qualified evacuation of patients.
- Analogous considerations for crisis reaction operations in different operational theatres produced similar results.
- A sufficient AE capacity providing intensive medical monitoring and the additional option of intensive medical treatment is a prerequisite for the provision of aid within the scope of humanitarian missions and also of other non-article 5 missions (civil-military cooperation) during a large scale damage event where the medical infrastructure is insufficient.



## 7.2 Medical Aspects

In view of the maxim of medical support during operations abroad, various traumata/posttraumatic conditions require a fast aeromedical evacuation from Role 3 to Role 4 for definite treatment and for the relief of the modular medical facilities (maintenance of personal medical care).

These include:

- Severely burnt patients, who can be evacuated to special clinics with comparatively little effort during the first 24 hours after incurring the burn and subsequent to first clinical treatment to ensure the provision of an adequate therapy (transplantation surgery, dialysis, intensive medical care).
- Polytraumatised patients with or without burns and an imminent posttraumatic, dialysis-requiring renal failure with the consecutive failure of several organs must be evacuated to medical facilities capable of providing dialysis, after emergency surgical treatment
- Neurologically traumatised patients, who, after the necessary neurosurgical treatment, must be evacuated to an appropriate level C medical facility for further care and rehabilitation (apallic syndrome, tetraplegia).

Toxicological diseases of patients exposed to chemical warfare agents indicate long-term respiration, especially in the event of inhalation traumata, which requires the evacuation from the operational theater to relieve local medical capacities (19).

In order to meet these requirements, fixed wing aircrafts have to be modified and equipped with state-of-the-art medical equipment. Germany is using the German Air Force Airbus A 310 as dedicated aircraft for strategic aeromedical evacuation, while the USAF is flying the C 17.

With the conversion of the Airbus A 310 to a freight configuration with a large freight door is it now possible to configure this aircraft for large-scale strategic aeromedical evacuation missions.

The AE A 310-300 medical conversion kits for the A 310 aircraft are currently in service to ensure long range transport of a minimum of 250 patients a day. (24)

The conversion kits have a modular configuration. Allowing the implementation of various configurations, a maximum of 38 stretchers, 48 seats and 6 intensive care stations can be installed.

The intensive care units (patient transport units) have been designed to the most advanced aspects of medical engineering. They are compatible with civil aircraft types and can be employed globally. The conversion kit also includes a laboratory unit. The provision of a telemedical terminal is planned.

A total of 4 sets, containing 54 stretchers, that can be refitted with up to 6 intensive care stations are to be procured.

## Aeromedical Evacuation



Fig. 2: Airbus A 310

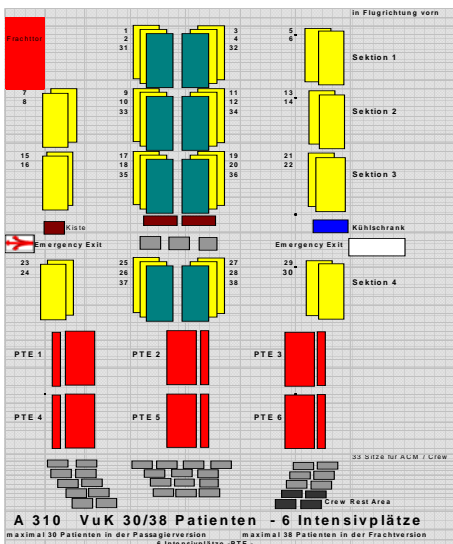


Fig. 3: Airbus A310 inside



Fig. 4: Patient transport unit

## 8. EXPERIENCES:

### 8.1 USAF Approach

In the US Air Force Critical Care Air Transport Teams (CCATT's) augmenting aeromedical evacuation crews are responsible for transporting critically ill/injured patients to medical centres. A CCATT typically consists of a critical care physician (surgeon, anaesthesiologist, emergency physician or pulmonologist), a critical care nurse and a cardiopulmonary technician. The CCATT's must be able to transport up to six unventilated (up to three ventilated) patients for 10-12 hours by air, using various aircraft including the C-17 Globemaster III and C-130 Hercules (6,12,13, Col Dr. Mark Ediger, HQ USAFE/ SG Command Surgeon, personal communication, ).