MIRF: A Close Look at an Intensive Care Aeromedical Evacuation Capability

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It is a well-documented fact that early intervention in the management of severe trauma cases improves recovery rates. Organic to this capability is the need to provide highly mobile medical facilities equipped with appropriate medical technologies. Dedicated medical platforms with onboard integrated medical systems, while desirable in some situations, are expensive and not always readily available in an emergency. Using a proven selection of portable, electromedical monitoring and resuscitation equipment contained in one convenient module, the Mobile Intensive Care Rescue Facility (MIRF) has been designed and developed to improve pre-hospital en route medical care capabilities. Primarily designed for Aeromedical Evacuation (AME) in the Australian Defense Force (ADF), the MIRF provides a "stand-alone" life support facility which can "go anywhere" and attach to almost any platform capable of carrying standard litters

Introduction

The exponentially increasing capital expenditure required to design and develop air and ground platforms dedicated to provide critical care facilities during transportation is significant.

A serious implication of customising road vehicles or aircraft for intensive care emergency operation is that inbuilt life support equipment tragically becomes unusable should the vehicle or aircraft become unserviceable. Further, should a transfer from one vehicle to another be required, the patient has to be disconnected from these inbuilt life-support systems to effect the transfer.

The MIRF

Designed by the author in the Faculty of Engineering's Biomedical Engineering Unit at the University of Southern Queensland, Toowoomba, Australia, MIRF is a technologically significant solution to efficiently and effectively use currently available electromedical monitoring and resuscitation equipment in several scenarios.

Its design achieves compliance with current road and aviation standards, particularly for structural integrity and electromagnetic compatibility.

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It is the uniqueness and simplicity of the MIRF which makes it such an efficient and cost-effective system for use in *battle casualty situations, tactical and strategic* AME, and in *field hospitals*.

The Concept

The MIRF integrates patient, litter, and equipment into a single system. It is biomedically engineered to incorporate aeronautical, mechanical, electronic, electrical, and materials engineering into one highly mobile capsule.

The concept opens new horizons in rescue and transportation strategies. The MIRF can be used as a stand-alone system anywhere. It can be winched or parachuted into difficult rescue scenarios. It can be carried by ground personnel, placed in any vehicle, aircraft, or ship and most importantly, the patient can remain connected to its life-support systems from the trauma point to the hospital, irrespective of the mode of transport.

The MIRF concept minimizes the need to purpose-build intensive care ambulances or aircraft. Existing transportion can therefore be used, thus enhancing the service, decreasing the response time, and reducing the capital expenditure of modification and construction of specialist vehicles.

Description

The external profile of the MIRF has been designed to fit into a variety of aircraft and ambulance

vehicles. Its carrying handles have the same dimensions as the North Atlantic Treaty Organization (NATO) litter which means the MIRF can be loaded or unloaded in the same time and with the same ease as the NATO litter.

Several types of stretchers can be used on the MIRF including the current NATO litter. The medical equipments, electronics, power, and oxygen systems are contained in a lightweight carbon composite capsule capable of withstanding the high inertial loads imposed by military and civilan aircraft design standards. The capsule has a folding door which, when open, exposes the medical equipment and when closed, renders the MIRF dust- and shower-resistant and physically protects the medical equipment during transit. This allows the MIRF to be safely dragged across the ground or lowered down cliffs. The carbon composite casing also assists in shielding the equipment from receiving or emitting electromagnetic radiation. Fold-away handles for manual transportation are provided and the MIRF can even be carried on its side for enhanced maneuverability, such as encountered on ships.

Equipment

A comprehensive suite of medical monitoring and resuscitation equipment is contained in the MIRF capsule. The equipment has been carefully selected based on its medical capability and suitability, size and weight, ability to withstand the environment, and its power requirements. Currently, this includes an infusion pump, a syringe pump, and air/oxygen ventilator, electrical suction, a multifunction monitor, and a defibrillator. In addition, the MIRF carries its own oxygen and electrical power supplies.

Oxygen System

Two 440-liter capacity oxygen cylinders providing about 1 1/2 hours of ventilation are included in the MIRF capsule. Mechanical ventilation is provided using a transport ventilator connected permanently to the oxygen bus. The infused volume and the breathing frequency can easily be adjusted by the operator. In addition, an air/oxygen mix is provided where this is indicated. The output gas circuit of the ventilator is constantly checked by an alarm monitor which indicates either over pressure due to airway occlusion or under pressure due to a leaking airway. The upper and lower limits of these alarms are also operator adjustable. A demand breathing facility plus an oxygen therapy capability is also available. If necessary, the oxygen supply can be replenished in transit while it is being used by changing one cylinder at a time. Pressure gauges and low pressure alarms advise the operator when to change a cylinder. External oxygen can also be connected at anytime if the host vehicle is so equipped.

Electrical System

The MIRF is fitted with a unique power supply which provides battery back-up and automatic battery charging from a wide range of external power sources. These include:

- Any direct current supply between 10 and 40 volts. This allows the MIRF to be powered from partially discharged automobile batteries (normally 12V) or aircraft (28V) power sources.

- Any alternating current supply such as the American 120V, 60Hz system, or the Australian/ European 250V, 50Hz system or aircraft 120V, 400Hz systems. This provides the MIRF with an international power supply system.

- In addition, the MIRF carries its own 12Ah sealed lead acid battery and charger which is used as auxiliary power to backup individual equipment.

Electromagnetic Compatibility

Some of the most challenging engineering work arose in attempting to have the MIRF certified to fly in civil and military aircraft. This meant compliance in all respects with Civil Aviation Authority Air Navigation Orders and American Military specifications, particularly for structural and electromagnetic compatibility aspects. Most countries acknowledge the military specification known as Military Standard 461 defining limits for conduction, radiation, and susceptibility. The MIRF is certified as complaint with MIL-STD-461, civil aviation, and military standards in Australia.

Military and civilian airworthiness requirements in the areas of structural, composition, electrical and oxygen systems, fire resistance, safety equipment, and environmental conditions for the MIRF have also been addressed.

Operational Aspects

The MIRF underwent its first operational trial when the ADF committed a tri-service medical support force to Operation Tamar in support of the "United Nations Aid Mission In Rwanda" (UNAMIR II) from

August 1994. Rwanda is a small, landlocked, and mountainous nation within central Africa. In April 1994, a genocidal frenzy and subsequent civil war left over half a million people dead and thousands injured. The Australian Medical Support Force (AUSMED) was tasked to provide a Level 3 resuscitation/surgical capability, limited humanitarian aid, and aeromedical evacuation capability to UNAMIR II.

Rotary wing in-country *tactical* AME and international fixed wing *strategic* AME missions were flown in a variety of airframes. These AME missions were flown after initial ground and flight configuration trials. A MIRF mounted on its trolley within the resuscitation area provided a convenient stand-alone platform from which all primary life support intervention and monitoring could be performed.

Tactical AME missions involved the MIRF being moved by road with an AME team and secured within a Bell 412 helicopter with a standard NATO litter kit (Figure 1).

Fig 1.

At the retrieval destination, most priority two casualties were lifed on NATO litters and placed onto the pre-positioned MIRF. For casualties requiring ventilation or stabilization, the MIRF was removed from the airframe, life support and monitoring established, and subsequently, the MIRF/casualty combine refitted to the airframe (Figure 2).

Casualties transported in this manner frequently remained on the MIRF through the evacuation chain until final transfer onto an operating theater table at the level 3 facility (Figure 3).

During inter-hospital *strategic* aeromedical evacuation of ventilated, intensive care patients, the

Fig 2.

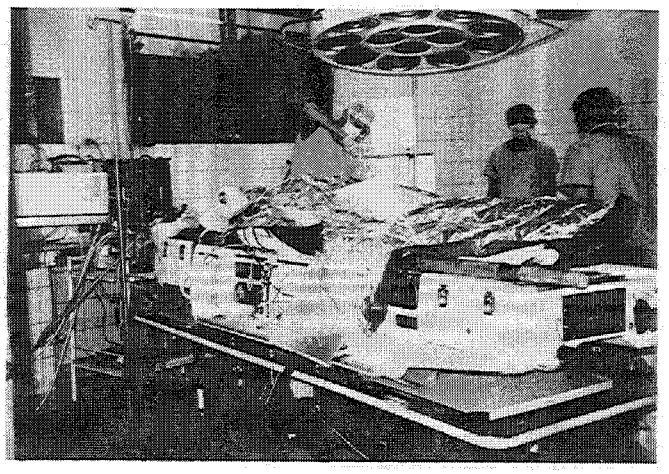

Fig 3.

casualty was placed onto the MIRF within the AUSMED facility and subsequently moved through the evacuation chain by road ambulance, then aircraft, and then road ambulance again to the destination hospital (Figure 4).

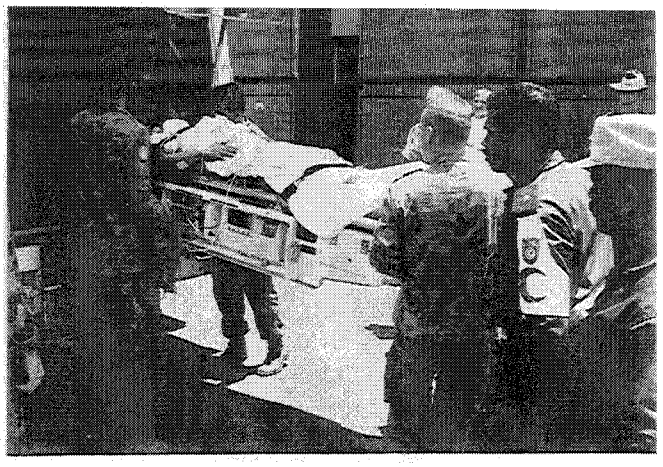

Fig 4.

These 4- to 5-hour missions often required novel airframe and vehicle fits and highlighted the flexible and convenient nature of the self-contained unit. Aircraft used were the Hercules C130, Spanish CASA, and Russian Antonov AN26 (Figure 5).

Conclusion

The MIRF is a fully self-contained, mobile, airworthiness-certified, intensive care medical life-support system rugged enough to meet both civilian and military requirements for emergency rescue and ambulatory applications. It provides a stand-alone life-support system anywhere in the field, in a hospital, on the edge of an airstrip, in a tent, in an aircraft, road vehicle, or even in the cabin of a ship. All of its leads and sensors are contained in one highly mobile, module-connected ready-to-go at a moment's notice, which significantly improves emergency response times.

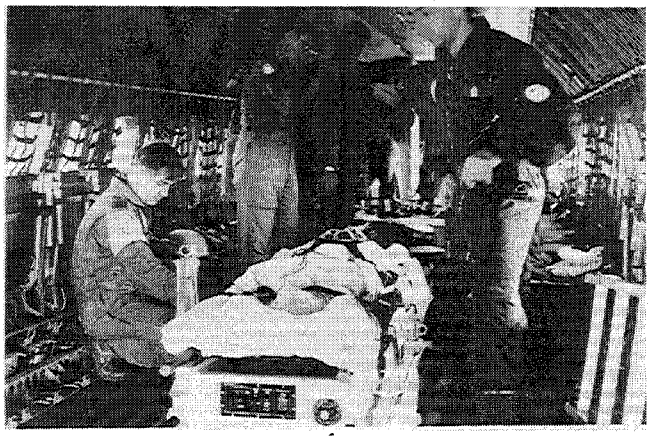

Fig 5.

The modular design of the MIRF with its flexible power and oxygen supply is a valuable asset in the conduct of both *tactical* and *strategic* AME missions. The carbon composite structure, proven in an operational environment, houses reliable electromedical components. It is concluded that in concept and practice, the MIRF is an advanced, intensive care, aeromedical evacuation facility for use by Defense Forces in the management of high dependency casualties.

Reference

Gardner T. "Operational Evaluation of the MIRF." February 12, 1995.