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Equipment

The CareFlight Stretcher Bridge: A Compact Mobile Intensive Care Unit

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SUMMARY
A mobile intensive care module has been developed for aeromedical transport of the critical care patient. It incorporates monitoring, ventilator, oxygen and suction, and infusion pumps. The device clips to a lightweight stretcher, over the patient at hip to knee level. This system is compatible with nearly all patient transport vehicles and allows monitors to be run from vehicle power. An assessment of the system after more than 500 transports is that it represents a significant advance over systems used previously. The advantages and disadvantages of the system compared with unmounted or vehicle-mounted equipment are discussed.

Key Words: INTENSIVE CARE: transport, retrieval, ventilation, monitoring; VENTILATION: intensive care, retrieval

The risks and problems associated with the transport of critically ill patients have been well defined,[1,2] especially in the case of head-injured patients.[3] Equipment essential for mobile intensive care has been outlined[4] and several mobile intensive care units have been described for use both within[5] and outside hospitals[2,4,6-9] (and personal communication — The Griffith Base Hospital Stretcher Bridge — H. P. Roby). The systems described for out-of-hospital use have all been designed specifically around a specific vehicle or class of vehicles, restricting versatility.

Over the past three years, the N.S.W. Medical Retrieval Service, the medical division of CareFlight, has transported over 1100 critically ill and injured patients. Sixty-five per cent of patients have required ventilation. The largest single diagnostic group has been head injuries (29%). Recurring problems with the use and carriage of complex life-support and monitoring equipment has led us to develop a mobile intensive care unit appropriate to the nature of patients we deal with, and compact enough to be used in any ambulance vehicle, including light helicopters.

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Requirements

Within the scope of our operation, multiple vehicles including road, fixed-wing and rotary-wing ambulances may be used for the transport of a patient.

In designing our 'Stretcher Bridge', these requirements were identified:

1. The system should be capable of carrying all the monitoring and life-support equipment commonly required.
2. It should be compatible with all transport vehicles presently used in New South Wales.
3. In view of aircraft restrictions, it should be light and compact, yet meet relevant aviation safety standards, and improve the securing of the medical equipment.
4. Wherever possible equipment should be run off vehicle power supply during transfers.

The stretcher bridge concept and design satisfies all these requirements.

The main problem in achieving these goals was the lack of standardisation of stretchers within the N.S.W. Ambulance Service. At the time of design, there were five different types in use, none compatible with the medical helicopters in N.S.W. It was therefore decided that this could best be overcome by utilising a lightweight helicopter-compatible stretcher as part of the system, and that the entire system would be secured on top of ambulance stretchers as required. The stretcher chosen was the Ferno Washington No. 9.

DESIGN FEATURES

General layout

The general concept was of a multi-storey tray, mounted to the stretcher at hip level, thus permitting (a) performance of CPR if required, and (b) the raising of the stretcher back to sit the patient up.

Construction

The frame of the bridge is constructed from 13 mm stainless steel square tubing, while the panels are 2 mm stainless steel. The attachment feet are an inverted U shape, of 6 mm steel, drilled for self-locking P.I.P. pins (see below).

The weight of the components of the system are:

Bridge:	9.4 kg
Stretcher:	10.8 kg
Equipment:	17.2 kg
Total:	37.4 kg

As the maximum load weight of the stretcher is 152 kg this allows a maximum patient weight of 124 kg.

FIGURE 1.—Complete mobile intensive care module including: Ferno Washington stretcher, stretcher bridge and Thomas medical pack.

Assembly

The stretcher bridge is attached to the stretcher by means of four self-locking P.I.P. pins which pass through holes in the four feet and underneath the stretcher tubing. As such, there has been no modification to the stretcher to accommodate the bridge. This has avoided the potential problem of drilling holes in the stretcher, which may weaken it. The inside surface of each foot is rubber-lined to prevent slippage once the pins are in place.

The stretcher and bridge combination meets CAA specifications for structural strength for both helicopter and fixed wing aircraft usage.

Equipment

The equipment that can be used in the stretcher bridge is variable at design stage, provided that it will fit within the main shell.

Equipment is secured either into brackets, with screw clamps or straps, or by handwheel bolts into threaded inserts in the equipment.

The items installed on our first two bridges are:

	Mark I	*Mark II*
Infusion pumps	Terumo Syringe Pump (x 2)	Terumo Syringe Pump (x 2)
Ventilator	Drager Oxylog	Drager Oxylog
Disconnect Alarm	Clements Ventalarm	SC CareFlight Pressurelarm
ECG	Lifepak 5 (Monitor Module)	Criticare 504USP
Oximetry	Criticare 501 +	Criticare 504USP
Blood Pressure	Clements Lifestat 100	Criticare 504USP*
Oxygen/suction	CIG Twin-O-Vac	CIG Twin-O-Vac

*Utilising an aneroid sphygmomanometer and pulse wave form analysis.[10]

A Datex transport capnograph has been included in the Mark II bridge on a trial basis. Suction equipment, self-inflating resuscitator, monitor leads, etc., are stored in a rear compartment.

Defibrillation has been necessary in only four out of 1113 patients. This is consistent with the experience of other groups transporting mostly non-cardiac critical care patients.[2,4] We therefore did not include a defibrillator in the bridge, but one is carried on all transfers.

It was also decided not to incorporate an oxygen supply in the bridge, but rather to have a three-metre standard 410 kPa oxygen hose with standard D.I.S.S. fitting and rely on vehicle oxygen supplies. The hose branches inside the bridge to supply the ventilator and Twin-O-Vac suction unit.

The remainder of the equipment is carried in a Thomas Transport backpack (model ALS 100) weighing 17 kg. Contents include a full range of respiratory and circulatory resuscitation equipment and drugs.

Electrical features

The experience of the authors with battery-powered monitors and infusion devices has not been satisfactory. We therefore wired the bridge to allow all the equipment (except the Lifepak 5, which has battery modules) to be connected through a single power cord designed for quick connection and disconnection. Each piece of equipment has its own circuit breaker on the back panel.

In the hostile environment of transport vehicles, some of the normal auditory cues are not audible (e.g. disconnection from the ventilator). In addition to the use of visual alarms, the audio outputs of all monitors are fed into the medical crew's intercom panels of our helicopter. For obvious reasons, the pilot and co-pilot's intercoms do not receive these signals.

Clinical usage

In the first nine months of usage, patients were transported in both helicopter and road ambulances. Approval to use the system in fixed-wing ambulances is still pending.

The system has been shown to fit easily into road ambulances and two different helicopters used by CareFlight during this period (an AS350B Squirrel, light single engine, and a SA365C Dauphin, medium twin engine).

Trials have shown the system is compatible with the N.S.W. Air Ambulance aircraft. For retrievals by road, the system is easily separated into bridge and stretcher, and with the stretcher folded, can be despatched by taxi, police car, or ambulance control car, thus sparing a road ambulance. The protocol developed for loading is to slide the stretcher underneath the patient on the patient's bed, then attach the bridge. Thus the patient can remain on hospital support systems and monitors until connection to the stretcher bridge equivalents. Conversely, the unit can be placed on the final bed at the receiving hospital, allowing connection to hospital equipment prior to disassembly. After the initial orientation, the system has proved easy to use. The complete loading process can usually be accomplished in less than four minutes; three to four minutes is saved on each inter-vehicle (road ambulance to helicopter or vice versa) transfer.

The added weight of this system has meant that four people are required to carry or load/unload the patient; offset against this is that no person is required to carry monitors or ventilate the patient. Ease of loading is

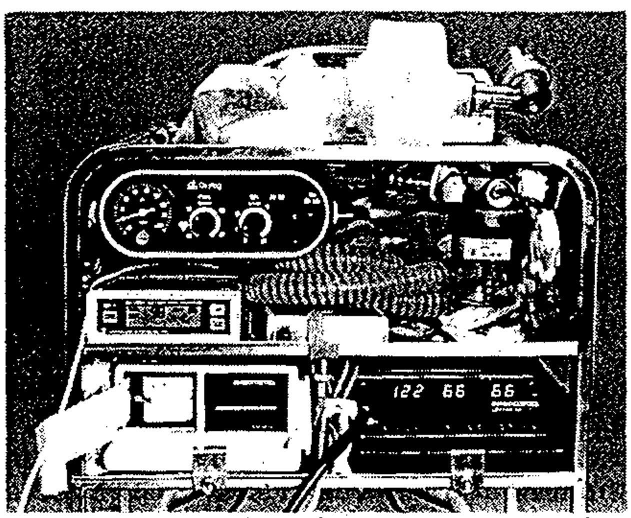

FIGURE 2.—Front view of Mark I stretcher bridge showing equipment installed.

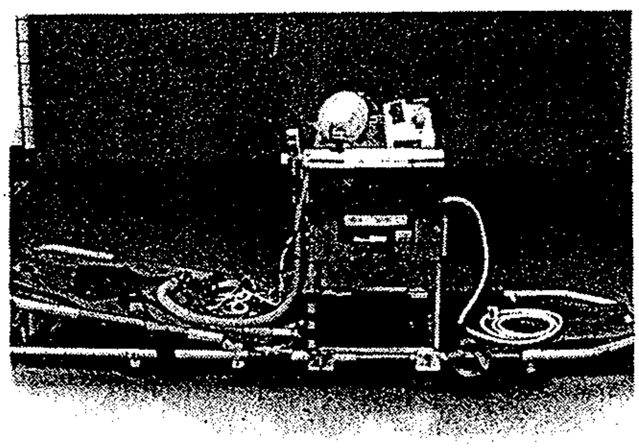

FIGURE 3.—Side view of stretcher and bridge, showing mounting system with one PIP pin installed and one removed. Note mount for additional syringe pump on top tray.

enhanced by castor-wheels on the stretcher. Slight top-heaviness of the system has been noticed only with paediatric patients.

The patient space under the bridge is sufficient for a large person with pneumatic anti-shock garment in place. The system has not significantly restricted tilting nor rolling patients laterally as required. One patient transported on this system sustained a cardiac arrest. This case and trials with a Resusci Anne® have shown that the stretcher bridge does not interfere in any way with CPR.

The system has significantly improved the visibility and access of equipment during transfer. The improved security against disconnections during transfers has been confirmed.

The system has been used in scene (pre-hospital) responses with equal success. It exceeds specifications for mobile intensive care equipment previously described for pre-hospital use,[8,11] and is multi-vehicle compatible. The only item so far to have proved incompatible with this system is the earlier of the two models of spinal board used by the N.S.W. Ambulance Service. This is too wide to fit on the stretcher and still allow installation of the bridge. For the trapped or semi-inaccessible patient, equipment such as a pulse oximeter can be easily detached from the bridge and taken to the patient.

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DISCUSSION

Three alternative approaches are possible for utilisation of monitoring and life support equipment in the pre/interhospital situation.

(a) Ad hoc approach, with equipment taken as needed, with no provision for mounting.
(b) Equipment is fixed mounted in the transport vehicle (detachable as required).
(c) The mobile intensive care unit concept, as previously described[2,6-9] (and personal communication H. P. Roby) and including this system.

The ad hoc option is clearly unsatisfactory, especially from the safety standpoint.

The fixed-mount option is widely used and was the option used on CareFlight's initial (Squirrel) helicopter prior to development of the stretcher bridge. Advantages include safe and stable mounting with ability to use vehicle power. However, full monitoring and support is dependent on the patient being in the vehicle; a significant disadvantage, given that some studies have suggested that risk of deterioration is greatest with the initial movement within the referring hospital.[2,12] Detaching equipment from fixed mountings to accompany the patient on a trolley or in another vehicle is possible if the installation allows for quick detachments. However, this means a reversion to the ad hoc approach for this section of the transport. A mobile intensive care unit approach combines the safety and the other advantages of fixed-mounted equipment with added versatility.

Most previous mobile intensive care unit designs have been built around a full-sized bed or trolley, and have been designed to be compatible with one single vehicle or vehicle type. Most of these designs have incorporated complete oxygen delivery systems including at least one oxygen cylinder.[2,5-9] In our design we had chosen to utilise fixed-mounted oxygen supplies already present in the transport vehicles we utilise, with a mobile intensive care unit concept for the monitoring and support equipment. This has proved a practical approach to reduce the mass of a mobile intensive care module. Outside the vehicles we use portable oxygen supplies such as an Oxy Viva, or a size 'C' cylinder with regulator. In over 500 transports we have not had a problem supplying oxygen in this fashion. In the helicopter, the defibrillator is mounted on a wall bracket and the Thomas pack secured with straps. In other vehicles they are able to be stowed within reach but secured. Outside the vehicles, the Thomas pack is backpacked and the defibrillator is easily carried by hand.

CONCLUSION

We have produced a mobile intensive care module with comprehensive life support and monitoring functions in a compact unit. It is more lightweight and versatile than previously described units and allows for patient support at scene responses, throughout transfer in multiple vehicles, and within the hospital but outside the definitive facility.

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