ORIGINAL ARTICLE

CRITICAL CARE IN AUSTERE ENVIRONMENT ANESTHESIOLOGISTS PERSPECTIVE

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SUMMARY

The provision of sophisticated medical care in an austere environment is challenging. Advances in medical technology provide the modern day field anesthetist with an extra edge to meet the challenges faced in harsh environments of the battlefield and enhance the survivability of casualties. The tasks of triage, resuscitation, and administration of anesthesia can be facilitated with the use of new airway devices, portable ventilators, and monitoring devices. These devices should ideally be portable, lightweight, rugged in construction, durable, easy to use, readily replaceable, and cost-effective. Before such equipment is used in the field, the anesthetist must carefully weigh the advantages and disadvantages and must be cognizant of the limitations of individual devices in different environmental settings. In spite of operating in adverse conditions, the Military Medical Services operate to professional standards of care comparable with their civilian counterparts.

Keywords : Critical care, Monitoring, Austere environment, Hostile conditions, Patient transfer.

Introduction

Out-of-hospital patient care, monitoring and transportation (retrieval) of critically ill patients within highly complex environments is a regular feature of military medicine. Adverse events/ incidents are not uncommon. Meaningful monitoring provides a means to better understand these occurrences and aid in better patient care. Familiarity with environmental adversities, medical equipment and updated clinical skills reduces the risk to patients and personnel and also allows for advanced patient care in the field.

Discussion

The provision of sophisticated critical care in an austere environment is challenging. Incident monitoring provides sufficient insight into retrieval incidents to be a useful quality improvement tool for retrieval services.[1] During and after a mass casualty event, it is likely that critical care services will be needed beyond an intensive care unit (ICU) setting.[2] Recent advances in critical care medicine provide the modern day field anesthetist with the extra edge to meet the challenges faced in the harsh environment of the battlefield and enhance the survivability of casualties. This is achieved not only by proper triage, apt resuscitation and usage of proper equipment but also by being imparted with appropriate training in managing these in such adverse environment.[3] The focus will have to fall on the education, evaluation, operations, patient-care skills, equipment, and telemedicine potential of the military medic.[4]

There is an increasing demand for anaesthesia at remote locations where the morbidity and mortality rates may differ from conventional operating room anaesthesia. However, no studies are currently available. On the basis of morbidity and mortality data from conventional operating room anaesthesia, we reached some important conclusions with regard to the safety of anaesthesia outside the operating room. A well-equipped anaesthesia machine, standard monitoring (electrocardiogram, oxygen saturation and non-invasive blood pressure), trained personnel and adequate planning should be standard for all out of the operating room procedures. When all these are in place, the incidence of morbidity or mortality should be comparable to that of anaesthesia provided in the operating room.[5]

The Limitations

If the field medical unit is in a fixed location environmental conditions and supplies of resources can be relatively stable. However, in major disasters or military threat, the medical unit / field hospital may have to move at short notice. This also applies to forward locations in highly mobile battle conditions. Medical units have to operate in all environments, usually without the benefits of climate control, ranging from air temperatures of up to 50ºC in hot, arid climates to-15 ºC or less and may be much lower when wind chill is taken into account in other extreme. Even in desert conditions, where day time temperatures are high, without cloud cover night temperatures may reduce to freezing or below. There are also the effects of rain, dust,

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mist and rapid changes of temperature and humidity at the same time. This is in marked contrast to conditions usually found in modern, heated or air-conditioned hospitals where most practitioners work.[6] The combined effect of all of these influences is to cause expansion, shrinkage, distortion, mould/microbial growth and corrosion. Equipment casings, seals, components and adhesives can degrade rapidly, which may interfere both with the functioning and longevity of equipment. Unreliability of monitoring equipment may result in critical incidents and patient harm. The shelf life of consumables for monitors may be reduced as well. To overcome these problems it requires that some equipment be modified and cared for or packaged differently.

Assessing the Equipment

Many of the above discussed issues are addressed when the equipment is assessed for transfers in military air transport, where a lot of the environmental factors listed above may be encountered. In the field environment the familiar audible and visual indicators which indicate machine malfunction may be lost because of increased background noise, low light conditions or other distractions. In these circumstances the monitors which monitor the medical devices themselves need to be observed more closely.[6]

The patient flow through a field hospital is very similar to a civilian hospital. Patients are directed to different areas according to their clinical needs as they progress through the field unit. Intensity of monitoring varies, escalating or reducing, according to the nature and stage of the patient's illness. In resuscitation areas clinical observation is supported by monitoring ECG, ventilatory frequency, pulse oximetry, non-invasive blood pressure and temperature. Other variables such as invasive pressures, arterial blood gases and end-tidal CO2 are measured as required. In the operating theatre the concentration of inhalational agents, inspired oxygen and end-tidal CO2, are routinely measured according to minimal monitoring standards for anaesthesia. This is particularly important to avoid errors when using apparatus such as draw over vaporizers, which are not routinely used in everyday practice. High-dependency and intensive care have the enhanced monitoring necessary to care for the critically ill. Monitoring strategies and equipment are adapted to allow for all potential scenarios.

Monitoring during Transportation of Casualty

The transport of critically ill patients always involves some degree of risk to the patient and sometimes to the accompanying personnel. Equipment and monitoring related complications have been reported[7,8] to range from 10-34% during transport. These include disconnection of monitoring leads, power failure due to incomplete charging; disconnections of indwelling catheters or vasoactive drug infusion, loss of nasogastric or chest tube, disconnection from the ventilator were among the most frequent problems. Most mishaps were noted at the destination site either before or during the procedure, but not during the actual transport. This can put patients to considerable risk of mishaps and can be avoided by appropriate attachment of monitors and fixation of indwelling catheters while preparing the patient for transport, use of trained personnel or special transport team, specially designed vehicle and setting appropriate transfer protocols. The decision on whether and how to send or retrieve a patient will depend on the urgency of transfer, the availability and experience of staff, equipment, and any delay in mobilizing a retrieval team Optimal resuscitation and patient preparation can reduce the complications associated with intrahospital transport.[9,10]

Military doctrine states that care should be seamless, continuous and progressive throughout the evacuation chain. With extended timelines and this expectation, the standards applied in routine practice are not sufficient. Many of the features required for monitoring equipment used for long transfers in difficult circumstances are overlooked, misunderstood or not implemented by manufacturers. These include effects of the surroundings on the devices and the effects of the devices on equipment nearby. Often equipment used for transferring patients in civilian practice does not fit the desired profile well and even that supposedly designed for transfers is often inadequate. Equipment that is used for transfers must be, rugged and highly reliable. It must have sufficient internal power for the duration of the transfer and additional capability for unexpected delays. If battery life is limited the batteries must be able to be replaced, or the device must be capable of utilizing multiple power supplies (aircraft supplies, vehicle supplies, external batteries, inverters, and mains supplies). Changing batteries or power supplies preferably should not interrupt the device's function. Devices must also be restrained appropriately while in use, as they may be exposed to considerable 'g' forces and vibration in aircraft or even surface vehicles. Suitable tie-down systems, straps and clamp systems are needed. Transferring patients directly from the battlefield causes other difficulties. This may be by land or air, but invariably, frontline vehicles used in evacuation of casualties are designed for operational survivability and little consideration is given to space or comfort. Not only is monitoring extremely difficult, but even basic care is hard to deliver and combat 'scoop and run' often precludes detailed monitoring.[11]

Military air transfer may be fixed or rotary wing aircraft and may be tactical or strategic. Forward tactical transfer is usually by rotary wing, because it is fast and flexible, being able to avoid ground hazards and obstacles. The mission of aero medical evacuation of patients, whether in peacetime, wartime or under unexpected conditions (earthquake, flood etc) will remain the same. Aero medical evacuation systems have become an integral part of the practice of critical care medicine. These systems provide interhospital transport of critically ill or severely injured patients. Understanding the medical aspects of flights and the capabilities of the aero medical environment will help to evacuate patients in a safe and a proper manner.[12]

Tactical transfers vary from a few minutes to 1 or 2 hours. Longer missions are unusual, because other considerations, such as the range of the aircraft, are important. It is also more difficult to provide increasing levels of care with a continually moving patient. This is most significant in primary evacuation, because a patient may not be fully resuscitated and deteriorate unacceptably without definitive interventions. Logistic issues are considered when planning. Tactical fixed wing missions are used to access higher levels of care or the onward strategic evacuation chain. Intra-theatre tactical transfer may be in rotary or fixed wing aircraft, depending on circumstances. Fixed wing transfers in tactical aircraft are not usually for longer than around 4 h, with well-stabilized patients. These times are based on accepted clinical considerations of care of the sick and wounded from the military doctrine. Observing timelines reduces the opportunity for the patient to deteriorate in the adverse conditions of the tactical environment, the aim is to deliver the patient in as good a condition as they were when the transfer began and ideally they should improve. Patients who are critically ill may deteriorate despite best efforts, but this should not be attributable to the transfer itself.[13]

Technical difficulties

Though the minimal monitoring standards require the monitoring of inspired oxygen and end-tidal CO2 in ventilated patients these are subjected for variations due to changes in altitude. Partial pressure decreases as an aircraft gains altitude, even with pressurized cabins, although the percentage of the gases remains the same as those at sea level. As a result the devices under-read the oxygen percentage at altitude, although the value on the readout gives the 'equivalent' sea level FIO2.[14]

More sophisticated devices may have barometric pressure compensation built in. With portable devices a correction factor may need to be applied to obtain the correct concentration or a manual recalibration at ambient pressure may be possible. Unlike oxygen monitors, end-tidal CO2 monitors are unaffected by altitude in the ventilated patient. If the patient's CO2 production is constant the end-tidal partial pressure remains the same. The end-tidal partial pressure of oxygen and nitrogen, however, fall with altitude and therefore the actual percentage of CO2 rises despite this. In the spontaneously breathing patient, who is compensating for hypoxia at higher altitudes, end-tidal CO2 will decrease as a result of hyperventilation, but this is not an issue at normal cabin altitude unless lung function is abnormal to begin with, and is negated by adding inspired oxygen.

Side-stream Capnography is susceptible to water in sample tubes and machines using this system are not usually designed for anything other than short transfers. The pumps used in these systems often consume a lot of power. Mainstream measurement is practical, but also uses considerable power which needs to be allowed for and adds weight to tracheal tube connections. When power is a consideration for a monitor, regular measurement of arterial blood gases is a better option, provided other disconnect alarms are adequate.[6]

Some ventilators do compensate for changes in the gas density and viscosity that occurs with change in altitude on their own while others have to be adjusted manually. Flow generators are less prone to these variations. Close and vigilant monitoring of respiratory variables is mandatory to avoid these issues. The ventilator being used in flight must be used before and the person accompanying the patient must be well versed with the intricacies of the machine. Changes in the ambient pressure affect functioning of the equipment and components especially if containing air. This is seen when the pressure is reduced and causes monitoring transducers to dampen in arterial and venous pressure lines and reflect inaccurate reading. Diligent removal of air from these would avoid these issues. The air in the fluid can expand coalesce and can add to the complication.[15]

Balloons on catheters in the pulmonary circulation present a potential problem if they expand. Deflating them and reviewing the need for these devices reduces the hazard. Monitoring and support equipment also have items such as touch control pads which contain air and may be vulnerable to pressure change. The disposable items used with clinical monitors must be packaged to maintain their integrity and avoid contamination. The packaging contains gas and may be damaged as they expand at altitude and must be carefully inspected before the item is used.[6]

Clinical monitoring such as palpating the pulse, measuring blood pressure, viewing respiratory patterns and seeing color changes is often difficult or impossible in aircraft. This is because of reduced or altered lighting, noise and vibration. Additionally an aircraft is mobile in three dimensions and exerts inertial forces on the crew, patient and equipment. In these circumstances monitors may also become unreliable.[15] Variables such as ECG, non-invasive blood pressure and pulse oximetry are subject to the generation of multiple artifacts. In these conditions alarms may be activated inappropriately. In view of the inability to rely on clinical signs and the paradox that machine-monitored variables are of greater importance yet potentially unreliable presents a dilemma. To overcome this, enhanced monitoring must be undertaken and measures taken to ensure the accuracy of what is actually measured. The limitations of space and lighting within the aircraft environment may impair visibility for reading the monitor screens and hence only those which have a large screen should be selected for this purpose.[15] To deal with extremes of temperature, insulation or larger heat skins may be applied to components.

The screens, computer processors, transformers and other electrical components of critical care monitoring devices may produce significant electromagnetic interference or electromagnetic compatibility which can interfere with the monitoring and meaningful interpretation and adequate precautions should be taken to avoid these.[16,17] This can be avoided by providing casing to the devices so as to have adequate insulation from these external influences. The equipment should be air transport worthy and should meet the criteria of the test variables.[18] It is more appropriate that the team using the equipment is responsible for servicing and user checks as they have ownership of any subsequent problems.[19,20]

Preparation and Planning

Human factors are extremely important in the field as it is a high-stress environment. If the human factors are not addressed, regardless of how effective the monitors are, there will be a failure to recognize abnormalities. Organization and high-quality training are the key to success in the field,[6] provided the equipment meets the required criteria. Each item must be understood in detail to avoid making fundamental errors regarding capability, function, mode selection and alarm indications. The commonest mistakes made during transfers are overestimating battery life and misunderstanding mode settings. Monitors of these variables must be accurate, user-friendly and understood. Detailed training also does much to reduce errors of and allows standards to be properly assessed and maintained.

Accepting functionally inferior machines adds risk to the patient or negates previous progress that the patient has made. Aero medical transfer of critically ill patients is one of the most demanding areas of medicine and should only be undertaken by those who are specifically trained and equipped.[20] This reduces the risk to the patient and stress on personnel.

Conclusion

The mission and the challenges involving patient care in field and their aero medical evacuation, whether in peacetime, wartime or under unexpected conditions (earthquake, flood etc) will remain the same. Understanding the medical aspects of flights and the capabilities of the aero medical environment will help to evacuate patients in a safe and proper manner. Advances in medical technology provide the modern day field anesthetist / intensivists with the extra edge to meet the challenges faced in the harsh environment of the battlefield and enhance the survivability of casualties. Effective monitoring in the field demands the appreciation of a number of factors.[21] It depends on having an understanding of the rigors of the environment and a thorough knowledge of the capabilities and limitations of devices being used. Personnel must be properly trained to survive and function in the environment, as well as be able to care for and protect their patients. This requires that they are current in clinical practice and have undertaken a detailed training. Meeting these requirements reduces the risk to patients and personnel and allows for advanced patient care in the field.

References

1. *Flabouris A, Runciman WB, Levings B.* Incidents during out of hospital patient transportation. Anaesthesia Intensive Care, 2006; 34(2): 228-36.
2. *Grissom TE, Farmer JC.* The provision of sophisticated critical care beyond the hospital: lessons from physiology and military experiences that apply to civil disaster medical response. Crit Care Med, 2005; 33(1 suppl): S 13-21.
3. *Tang KC, Chiu JW, Low E.* Airway and ventilatory equipment in field anaesthesia: What's New? Mil Med 2004; 169 (5): 342-8.
4. *De Lorenzo RA.* Improving combat casualty care and field medicine: Focus on the military medic: Mil Med 1997; 162 (4): 268-72.
5. Air, water and difficult terrain ambulances. Medical devices interface requirements for the continuity of patient care. BSEN 13718: 2002. Available from http://www standardsdirect.org/ standards/standards1/StandardsCatalogue24,view 11040 Html.

6. *N. M. Mc Guire*. Monitoring in the Field: British Journal of Anaesthesia 2006; 97(1): 46-56.
7. S*mith I, Fleming S, Cernaianu A*: Mishaps during transport from the intensive care unit. Crit Care Med 1990; 18: 278-281.
8. *Uusaro A, Parviainen I, Takala J, Ruokonen E*. Safe long-distance interhospital ground transfer of critically ill patients with acute severe unstable respiratory and circulatory failure. Intensive Care Med 2002; 43(9)2: 1122-1125.
9. *Corfield AR, Thomas L, Inglis A, Hearns S*. A rural emergency medical retrieval service: the first year. Emerg Med J. 2006; 23(9): 679-83.
10. *Duke GJ, Green JV*. Outcome of critically ill patients undergoing interhospital transfer. MJA 2001; 174: 122-125.
11. *Spiers G*. Resuscitation, riots and the police. New developments in ambulance resuscitation. Ambulance Services Institute Seminar, Telford, April 2006.
12. *Mentes MO, Akinci H*. Aeromedical evacuation of critically ill and injured patients: Ulus Travma Acil Cerrahi Derg 2006; 12 (1): 1-8.
13. *Marx G, Vangerow B, Hecker H et al*. Predictors of respiratory function deterioration after transfer of critically ill patients. Intensive Care Med. 1998: 1157-62.
14. *Braman SS, Dunn SM, Amico A, Millman RP*. Complications of intrahospital transport in critically ill patients. Ann Intern Med 1987; 107: 469-473.
15. B*arthwick M, Mc Guire NM, Scott D*. How to prepare for the unexpected. Pharm J 2005; 275: 141-2.
16. Electromagnetic Compatibility of Medical Devices with Mobile Communications. Device Bulletin 9702. Medical Devices Agency publication, 1997. Available from http://www.nhra.co.uk.
17. Update on Electromagnetic Compatibility of Medical Devices with Mobile communications. TETRA (Terrestrial Trunked Radio System) and outside media broadcasts from hospital premises. Safety Notice 2001(06). Medical Device Alert. Medical Devices Agency. March 2001. Available from http://www.nhra.co.uk.
18. *Rainford DJ, Gradwel DP*. Ernstings Aviation Medicine, 4th Edition, London: Hodder Arnold, 2006.
19. Generic Specifications for Special Purpose Aeromedical Equipment (SPAME) – Final issue. 4, ERA Technology Report Feb 2006. Available from http://www.nhra.co.uk.
20. Strauss B, Morgan GM. Everyday threats to aircraft safety. Issues Sci Technol, 2002/2003: 82-6.
21. *Young D*. Does monitoring affect ICU outcome? Joint R CoA/ BJA Symposium on Clinical Monitoring, 2006: 15-16.

BOOK REVIEW

ANAESTHESIA- 500 ONE BEST MCQS

by

Prof. Fauzia A Khan - Pakistan

Assessment or evaluation is an invaluable component of any curriculum, as it helps to ascertain whether curricular goals have been accomplished or not. With the deficiencies of the traditional assessment systems being identified, there has been resurgence of interest in adoption of objective structured clinical evaluation (OSCE) methods across the globe. MCQs can be of ammense help in such kind of objective evaluations. As has been pointed by the author herself, construction of best MCQs by individual item analysis, not only is time consuming, but is also difficult, especially for the inexperienced.

This book can be used as ready reckor for all those who are planning OSCE stations and also for all those trainees or consultants who like to perform self assessment/appraisal as a part of their continuous professional development.

I honestly recommend this book for all categories of anaesthesiologists who like to be self directed learners.

Dr. P. F. Kotur
Editor