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Medical Care Under Extreme Conditions: Options For Equipment

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Views represented in this booklet are solely those of the author and do not necessarily represent those of Smiths Medical

This booklet is designed to help you understand:

1. Medical care under extreme circumstances
2. Natural and man-made disasters in peace and war
3. The medical problems presented by extreme circumstances
4. The requirement for equipment that will operate successfully under extreme circumstances

Introduction

Modern medicine depends increasingly on essential services such as electricity, water, sterilization services, piped and bottled gas supplies, drugs and equipment re-supply and servicing. Much of the equipment provided for hospital and even pre-hospital care is based on the assumption that such essential services will always be present. However, both natural and man-made disasters in recent years have revealed the vulnerability of modern medical equipment when the infrastructure is disrupted. In these conditions breakdown in essential services can occur quickly and a large number of unexpected casualties can overwhelm hospital facilities. The increasing problem of terrorist attack and a surge in casualty numbers as a result has revealed the vulnerability of hospital and pre - hospital services in both developing and developed nations.

The constant technological progress in medicine in a stable environment should be matched by a continuing ability to provide a high standard of medical care in situations where the normal infrastructure is damaged or absent. There is an important link in identifying equipment that will function in both developed and developing nations where medical facilities are often basic and may be quickly overwhelmed.

The term "medicine in extreme circumstances" (MEC) can be used to describe medical challenges over a range of situations ranging from a breakdown of normal developed hospital resources, through disaster and military medicine to locations where there may be little or no support structure.

The object of this short booklet is to consider what options are available for equipment that will continue to work when circumstances are extreme.

Providing Medical Equipment In Extreme Conditions

Extreme circumstances can cover a wide range of conditions ranging from natural disaster to deliberate acts of war.

The following are examples:

1. Conventional urban medical and surgical practice where support services break down as a result of natural or man-made disasters or other situations which produce a casualty overload.
2. During epidemics in urban and rural areas.
3. Emergency medical care in contaminated zones, following release of a toxic chemical.
4. War zones, where medical support always requires special equipment and training, together with specialised logistic support.
5. Humanitarian aid operations in developing countries, where equipment transported from developed nations may be inappropriate and unsupportable due to infrastructure and local socio-economic and climatic conditions.
6. Wilderness and other remote location medicine such as mountain and sea rescue.

The equipment used in extreme conditions must be :

1. **Autonomous (not dependent in mains power and central compressed gas supplies)**
2. **Simple to operate and intuitive**
3. **Robust and compact allowing easy transportation and deployment under difficult conditions**
4. **Versatile**
5. **Capable of operating under extremes of temperature, humidity and other climatic conditions from the jungle to the desert**

Medical equipment under extreme conditions

It should be the aim of MEC to provide the best care possible. In developed countries normal prehospital care is provided by medical and paramedical teams who carry a variety of equipment capable of providing life support and other care similar to that found inside the hospital. Ventilators, syringe pumps and other equipment is used that can run on compressed gas, batteries or a generator. Also, vehicle power supplies can provide back up power. In some countries specially equipped mobile intensive care units with medical teams are able to operate independently outside the hospital.

When the normal support structure fails equipment for used normally for emergency and pre-hospital care is the fall back for providing MEC. Such equipment will be equally appropriate for developing countries where the hospital infrastructure may not be as developed as in other parts of the world.

Battlefield medicine

Battlefield conditions present a severe test of medical equipment. Although power from batteries or a generator is assumed in modern warfare any equipment used must be constructed to high standards. Battlefield medicine must use equipment that is rugged, transportable, durable, reliable and simple to operate. Bottled oxygen is particularly scarce. Resupply often has to be by helicopter and weight is a major consideration. Other means of operating ventilators and anaesthetic equipment which conserve oxygen are required.

Field anaesthesia provides a good example of MEC. In modern hospital practice, simple anaesthetic techniques have largely been replaced by modern high-technology equipment that relies on power and gas supplies. Experience with more basic equipment may be limited. MEC anaesthetic equipment is designed to provide high quality anaesthesia without the infrastructure need to support modern hospital equipment. Such equipment must be simple, rugged, transportable, independent from central power and gas supplies and easily serviceable.

Chemical, biological, radiological and nuclear (CBRN) incidents

Chemical and biological releases may be either accidental or deliberate (from terrorism) and can give rise to areas of contamination with casualties trapped inside who require decontamination before they can be moved to hospital. Life support and other medical may be required in these circumstances. Special equipment is required that can be transported into a contaminated zone and operate within it. Many emergency medical formations around the world now train and equip personnel to work in protective suits within CBRNE incidents. The life support equipment they use must be simple and straightforward.

Disaster medicine

Natural and man-made disasters can strike anywhere in the world and affecting both developed and developing nations alike. In developing nations natural disasters may have a devastating effect on an already fragile medical infrastructure. Responses often require outside medical help through international agencies and other organisations. Equipment is required that can be prepacked and transported quickly to a disaster area. As with battlefield equipment, it must be rugged, resilient and simple to operate by medical responders who may not be familiar with it in their usual medical practice.

Disasters create mass casualties, disrupt supply chains and communications and can seriously affect even well-organised hospital responses making them unable to function.

Conventional to extreme practice: maintaining the standards

The idea that normal medical standards should be sustained despite disruption is implicit in the practice of extreme medicine. There should therefore be no lowering of standards because of the difficulties.

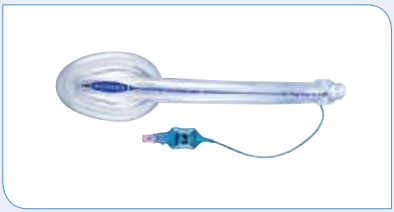
Modern medicine is governed by standards controlled by professional bodies. Anaesthesia practice for example is controlled by guidelines set out by the American Society of Anaesthetists in the United States and the Association of Anaesthetists in the UK. Thus the following equipment should be regarded as essential backup to normal clinical observation: oxygen concentration in the inspired gas and a low concentration alarm; pulse oximetry, ventilation high and low pressure (disconnect) alarms, ECG and automated blood pressure recording at intervals of 5 minutes. Although these standards are provided for anaesthesia given in conventional modern clinical circumstances they can and should be translated into extreme medicine to ensure quality of care.

Requirements for medical support under extreme conditions:

1. **An understanding and awareness of the problems by professional medical bodies**
2. **Special planning and training for medical support formations to be able to apply modern medical care under extreme conditions**
3. **A logistic infrastructure that can respond quickly to the requirements of extreme conditions**
4. **Suitable equipment that can be used in extreme conditions**

Medicine in extreme conditions : what sort of equipment is required?

1. Life support equipment (airway, ventilation and circulatory support)



2. Emergency Airway Access

3. Special equipment for mass ventilation (following chemical exposure and epidemics where conventional facilities may be overwhelmed)

4. Anaesthetic and operating equipment (field surgery and anaesthesia)

5. Emergency pneumothorax and drainage

6. Vascular access and delivery (syringe pumps)

7. Essential equipment for continuing high-dependency care (essential intensive care)

8. Monitoring equipment (essentially oximetry and capnography)

9. Equipment that can be driven from a variety of power sources (AC/DC electricity, gas, ...)

10. Oxygen supply (compressed bottled gas and oxygen concentrators)

Oxygen

Providing oxygen therapy in extreme conditions is as vital as it is in hospital. Trauma often reduces the ability of the lungs to oxygenate blood breathing air and oxygen supplementation is necessary. In hospital practice oxygen is usually supplied from a central source via a compressed pipeline supply. In extreme medicine this will not be possible and so supply must be via:

- **compressed bottled gas**
- **oxygen concentrators**

Compressed gas may be supplied in bottles of varying sizes but duration of the bottle when being used becomes a major factor. Free flow oxygen supply, frequently used in hospital practice is very wasteful. Bottles have only an limited lifespan and cannot be replaced easily.

An alternative to free flow oxygen administration which is much more economical is demand oxygen therapy. Here a demand valve fitted to a portable gas-powered ventilator ensures that oxygen is only delivered when the patient takes a breath. Thus oxygen does not flow during the expiratory phase and there is no waste during this part of the respiratory cycle.

Ways of saving oxygen

The following measures can be taken to reduce oxygen wastage:

1. Avoid the use of free-flow oxygen therapy. Demand systems as found on PGPV are the most economical way of delivery oxygen to a spontaneously-breathing patient.
2. Use of compressed air as a carrier gas and driving gas for PGPV.
3. Use of oxygen concentrators.

Airway management

Most of the airway devices used in conventional medical practice can be used in extreme medicine. However circumstances and skill levels in conditions of patient overload (as in disaster medicine) may mean that conventional techniques such as endotracheal intubation may not be possible and here alternatives such as laryngeal mask insertion should be considered. Also where the surrounding conditions make conventional protected airway support impossible (such as entrapment or major trauma following explosion or building collapse) alternative devices such as the PCK (Portex® Cricothyroidotomy Kit) may be required to gain secure access to the trachea and allow ventilation during patient extraction and evacuation to hospital.

Ventilation

Ventilation in hospital ICU is usually done using electronically controlled devices that require both power and compressed gas for their function. Such devices are not designed to be used in the extreme medicine circumstances. They have neither the transportability nor the ruggedness for use in such circumstances.

Ventilation options in extreme conditions are found in portable gas powered or portable electrically driven devices.

These devices can be used in a range of circumstances including:

1. Primary rescue and resuscitation)
2. Stabilisation and transport
3. Longer term ventilation in high dependency units in hospital

A variety of options are available in portable ventilators.

Conclusions

Disasters can strike anywhere and can affect much of the infrastructure on which modern hospital medicine depends. Equally, in developing nations the level of medical infrastructure may be limited. In both situations equipment is required that can operate independently of power and other logistic supplies to ensure that medical care can continue to be given.

This is the essence of medical care under extreme conditions.

While much modern hospital equipment is designed only to be used with power and a protected environment equipment is available that can be used safely and effectively outside the hospital and in hospitals that have themselves been affected by disaster.

Planning for disaster and the provision of medical care under extreme conditions is essential for all modern medical practice. Natural risks continue and others such as the urban consequences of terrorism on both infrastructure and production of mass casualties are on the increase worldwide.

Equipment options must be explored that are rugged, simple and reliable.

Medical care depends on the fusion of knowledge and skills with the right equipment. Extreme conditions may provide a challenge, but one that can be overcome.

Suggestions for further reading and organisations

Responding to disaster, where to find more information:

- World Association for Disaster and Emergency Medicine (http://www.wadem.org/)
- World Health Organisation
- Koeing and Schultz's Disaster Medicine: Comprehensive Principles and Practices. 2009 (Edited by Koenig K and Schultz C. Cambridge University Press, Cambridge CB2 1BR, UK).

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