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Defibrillator/Monitors for ICU and Hospital Use

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Professor Gazmuri and Erika Kube review features and application of defibrillators which need to be taken into account in purchasing policies.

The risk (or presence) of life-threatening cardiac dysrhythmias often justifies admission of patients to hospital areas with capability for continuous electrocardiographic (ECG) monitoring and availability of personnel competent in the recognition and management of such dysrhythmias (i.e. intensive care units, emergency departments, telemetry units) (Gazmuri & Gopalakrishnan 2005). Comparable capabilities are needed during specific episodes of care such as surgical procedures, electroconvulsive therapy, cardio-respiratory stress testing, and transport of high-risk patients. For patients at low risk of life-threatening cardiac dysrhythmias – who are not admitted to monitored areas – hospitals have “safety-nets” composed of resuscitation carts and teams that can be summoned within minutes to the patient’s bedside.

Defibrillators are devices designed primarily to store electrical energy for subsequent delivery in the form of an electrical shock. Defibrillators are typically battery powered, but some can operate connected to an AC or DC power-line. The term defibrillation refers to the rapid delivery of electrical shocks, unsynchronized to the electrocardiogram, for the purpose of terminating ventricular fibrillation or other rhythms in which synchronization is precluded by either the urgency or lack of identifiable QRS complexes (i.e. pulseless ventricular tachycardia, ventricular flutter, and Torsade de Pointes). The term cardioversion refers to the delivery of electrical shocks synchronized to the R-wave of the ECG and is used for terminating organized tachyarrhythmias in patients who are usually haemodynamically stable (i.e. atrial fibrillation, atrial flutter, ventricular tachycardia, etc.). The shock is delivered immediately after recognition of the R-wave to avoid delivery during the vulnerable period which can precipitate ventricular fibrillation. The vulnerable period extends from 60 to 80 msec before, to 20 to 30 msec after the apex of the T-wave (Hou et al. 1995).

Automated External Defibrillators (AEDs) refer to devices with built-in capability for automated recognition of “shockable” rhythms (i.e. ventricular fibrillation and rapid wide complex tachycardia) (Liddle et al. 2003; van Alem et al. 2003). AEDs deliver only unsynchronized electrical shocks and are purposely designed for operation by individuals with training limited to basic life support (BLS) or no training at all. AEDs feature voice and screen commands that guide the rescuer through the process of shock delivery and resuscitation without requiring the rescuer to visualize and react to the underlying rhythm. AEDs are commonly available for public access defibrillation (PAD) and are carried by rescue squads with BLS trained first responders (i.e. police force, firefighters). However, AEDs can also be placed inside the hospital in non medical areas and in crash carts for use by individuals without advanced life support training (ALS) (Destro et al. 1996).

Manual Defibrillators on the other hand are designed for use by skilled operators – typically with advanced life support (ALS) training – capable

of recognizing and treating life-threatening cardiac dysrhythmias. The devices include a screen for ECG display and are also known as defibrillator/monitors. Manual defibrillators have the capability for delivering synchronized or unsynchronized electrical shocks. Many current defibrillator/ monitors have included AED capability with mechanisms for rapid switch from AED to manual mode enabling the device to be operated by BLS and by ALS trained individuals. Manual defibrillators with AED capability may be useful in areas in which BLS providers are expected to respond first, followed by ALS providers as a part of cardiac arrest or emergency response teams. Automated defibrillation requires prolonged hands-off intervals for rhythm analysis and shock advice, which during cardiac resuscitation may result in detrimental interruptions in chest compression (Berg et al. 2003). Thus, manually operated defibrillators should substitute AEDs or advisory modes as soon as trained personnel arrive. In addition to shock delivery, most defibrillator/ monitors have capability for external transcutaneous pacing with ventricular sensing, useful for the temporary management of bradyarrythmias.

Modern-day defibrillators are not only defibrillation/cardioverter/ pacemaker boxes; they are equipped with an increasingly sophisticated array of features some of which include capability for monitoring temperature, blood pressure, pulse oximetry, end-tidal CO2, and the ECG based on 3-, 5-, 7-, and 12-lead configurations. Most defibrillators also have capability for data recording and retrieval featuring electronic storing devices and protocols for data transfer to a PC or directly to a printer.

It is worth noting that the advanced monitoring capability of manual defibrillator/monitors is usually available in acute care areas (intensive care, operating rooms, and emergency departments), and integrated to clinical information systems. However, the advanced features become exceedingly useful when defibrillators are used outside monitored areas. Such is the case when defibrillator/ monitors are used for transport of high-risk patients or when responding to a cardiac arrest elsewhere in the hospital. Measurement of end-tidal CO2 in the setting of cardiac arrest enables verification of proper placement of an endotracheal tube and also serves to assess the amount of systemic blood flow being generated during cardiac resuscitation (Gazmuri & Kube 2003). Pulse oximetry allows continuous assessment of arterial oxygenation obviating the need for repetitive blood gas analysis. Blood pressure monitoring may help identify needs for additional haemodynamic interventions. The light weight of most available devices facilitates transport to the scene of cardiac arrest and other emergencies. In addition, Cardiac Science offers a defibrillator/monitor designed for use in individual patients throughout the hospital stay with capability for recognition of shockable rhythms and automatic delivery of electrical shocks (PowerHeart CRM).

With regard to defibrillation waveforms and energy levels, new AEDs and most manual defibrillators are engineered to deliver biphasic waveform shocks. Some manual defibrillators still feature monophasic waveform shocks and some have both waveforms available. With monophasic waveforms the current delivered flows in one direction. With biphasic waveforms the current reverses polarity through the shock enabling successful defibrillation with less peak current and less energy than with monophasic shocks, possibly causing less postresuscitation myocardial dysfunction (White 2004). Manufacturers continue to develop variations around the basic waveform configuration; however, substantive clinical differences have not yet been demonstrated beyond today’s consensus favouring biphasic waveforms. The lower energy requirement of biphasic waveforms has enabled the construction of lighter and more portable units. With regard to the energy levels, most defibrillators present a wide range starting from 1 or 2 Joules

and ending with 200 or 360 Joules, with 200 Joules being the recommended maximum for biphasic shocks, and 360 Joules for monophasic shocks. The wide range of energies allows defibrillation in patients of all ages (neonates, infants, children, and adults) and internal and external defibrillation.

When deciding which defibrillator/monitors to purchase, cost is not likely to be a deciding factor among brands, because prices of basic units (defibrillator/monitor) are similar. However, cost increases in proportion to added features. A purchasing decision should consider the intended use of the defibrillator/monitors identifying the specific features required. Ideally such decisions should be part of a hospital-wide initiative in which issues related to training, compatibility, service contracts, bargaining power, data integration, and track record of specific manufacturers are also considered. The solution for many hospitals has been to devise systems in which crash carts are equipped only with AEDs and code teams carry more advanced manual defibrillator/ monitors stationed in acute care areas.

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