Defibrillation

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ABSTRACT

Defibrillation may be needed in witnessed and unwitnessed cardiac arrests. Cardiopulmonary resuscitation (CPR) must be initiated and defibrillation administered without delay. Every shock cycle includes 1–2 minutes of CPR followed by rhythm analysis. The energy level for biphasic defibrillation of ventricular fibrillation is 150 J with possible step-wise escalation to 360 J. All healthcare workers need to learn and be authorised to use an automated external defibrillator (AED). In addition, all ambulances must be equipped with AEDs when transporting patients. Self-adhesive pads/paddles must be applied firmly to the skin for best effect. Monitoring electrodes and pacemaker locations should be considered during paddle/pad placement. AED skills should be imparted to a wide variety of community groups. More efforts will be made to increase the availability of AEDs in public, residential, commercial and industrial facilities.

Keywords: automated external defibrillators, energy levels, lead placement, pad position, public access defibrillation

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INTRODUCTION

Defibrillation remains a key strategy in the management of cardiac arrest victims. The most frequently documented rhythm in witnessed cardiac arrest is ventricular fibrillation (VF),[1] and the most effective therapy to date for this malignant rhythm is electrical defibrillation of the heart. As VF is transient, defibrillation must be immediately applied, failing which the probability of survival drops by a factor of 7%–10% every minute.[2]

CPR BEFORE DEFIBRILLATION

The current emphasis of good, uninterrupted cardiopulmonary resuscitation (CPR) to promote systemic and coronary perfusion with the aim of achieving sustained return of spontaneous circulation (ROSC)[3] raises the question of whether CPR should be performed prior to defibrillation. The need for this decision occurs only in a very specific situation where a life support provider with a defibrillator at hand witnesses a cardiac arrest. Should a good 1–2 minute CPR be performed before defibrillation, or should the victim be defibrillated immediately? Current evidence neither supports nor refutes a delay in defibrillation to provide a period of CPR. In all other instances, whether a cardiac arrest is witnessed or not, immediate CPR should be performed unless a defibrillator is available and can be applied on the victim without delay.[4-9]

Singapore National Resuscitation Council (NRC) recommendations

- In both witnessed and unwitnessed cardiac arrests, defibrillation should be performed immediately.
- If a defibrillator is not available or a delay in the preparation for defibrillation is anticipated, CPR must be initiated in the first instance and defibrillation carried out once the defibrillator is ready for delivery of shock.

CPR-DEFIBRILLATION SEQUENCE

In patients with persistent VF despite initial defibrillation, the CPR-defibrillation sequence is adopted. In this sequence, the emphasis is to provide good, uninterrupted CPR for 1–2 minutes in-between defibrillations. This CPR time frame promotes systemic and coronary perfusion and also helps to improve intravascular medication delivery when resuscitation drugs are used in the context of advanced cardiac life support. There is also the concern that human rescuer fatigue, which develops usually after at least one minute of chest compressions, should not be allowed to continue for too many seconds to the detriment of coronary perfusion and survival.

NRC recommendations

- Every shock will be followed by 1–2 minutes of CPR, at the end of which a rhythm analysis should be carried out to determine the need for further cardiac compressions or defibrillation.
- This CPR-defibrillation cycle is applicable for both out-of-hospital and in-hospital cardiac arrests.

COORDINATION OF CPR USING AED

Automated external defibrillatiors (AEDs) have protocols to guide users through a process of performing safe defibrillation. The required actions, usually simplified into

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three steps, are often delivered through voice prompts. Common to these protocols is a phase of rhythm analysis, followed by a period of automatic energy charge when a VF is detected, during which the life support provider is traditionally expected to 'stand clear'. In a practical sense, these are 'hands-off' phases where no CPR is performed, and are potentially detrimental to the survival of a cardiac arrest victim.

NRC will work with AED manufacturers and distributors to review the way AEDs that are used in Singapore deliver shocks, with the aim of reducing the length of these 'hands-off' periods. This will involve technological advancements in the ability of the AED to distinguish VF from motion artifact generated by CPR as well as changes in the instructional steps given by the AED voice prompts to the life support provider.

NRC recommendations

- AED algorithms to allow CPR to be continued during the rhythm analysis phase.
- AED protocols to allow CPR to be continued during the charge phase of the defibrillator.

WAVEFORM, ENERGIES AND STRATEGIES

The issue of biphasic vs. monophasic waveform for shock delivery was previously addressed in the NRC Singapore 2001 guidelines.[10] Since then, all new defibrillators use the biphasic waveform to deliver shocks. This spurt toward making biphasic defibrillation a standard is supported by evidence that the lower energy required actually achieved higher first shock success rates.[11] The definition of low energy is general taken as that of less than 200 J. Using lower energies also confers the technical advantage of creating smaller sized defibrillators, which are lighter, easier to maintain and have an extended battery life.

Manufacturers of defibrillators and researchers have also tweaked the biphasic waveforms with the aim of increasing the efficacy and effectiveness of defibrillation. Commonly known waveforms found in commercially available defibrillators include the biphasic truncated exponential (BTE), pulsed biphasic and rectilinear biphasic waveforms. Comparisons of these biphasic waveforms, however, do not reveal any significant advantage of one waveform type over another.

The declining favour for monophasic defibrillation is fuelled by the notions that it is less effective than biphasic defibrillation and its higher energy requirement may actually damage myocardium.[12] However, in terms of survival outcomes, monophasic defibrillation has not been shown to be inferior to that of biphasic defibrillation.[13] Moreover, human studies involving BTE waveforms with energy levels up to 360 J have not shown harm.[14,15] Therefore, monophasic waveform defibrillation still has a place in the management of VF. Several studies have shown that lower energy defibrillation (< 200 J) with biphasic defibrillators is safe and achieves VF termination with an efficacy that is better or equivalent to high energy monophasic defibrillation. Among the low energy regimes, there is evidence that the first dose energy level of 150 J is associated with higher shock-success rates as compared to lower energies,[15] even though lower energy levels such as 120 J have been used with reasonable efficacy. Following the first shock, subsequent shocks for VF may be delivered at the same or higher energy levels up to a maximum of 360 J.[14,15]

NRC recommendations

- With a biphasic defibrillator, the initial energy level for defibrillation is recommended to be 150 J, although there are defibrillators that are capable of delivering lower energy levels such as 120 J, with reasonable efficacy. It is permissible to escalate the energy level for the second and subsequent defibrillations up to a maximum of 360 J, depending on the capabilities of the device and the energy protocols adopted by the institution.
- With a monophasic defibrillator, the energy level for defibrillation of ventricular defibrillation is 360 J.

MANUAL VERSUS AUTOMATED EXTERNAL DEFIBRILLATION

Modern defibrillators are equipped to allow defibrillation in a manual or a (semi-) automated mode. The manual mode has the advantage of a shorter hands-off period,[16] but its correct application is operator-dependent. The manual mode demands its user to be conversant with basic electrocardiogram (ECG) reading skills and the ability to accurately identify VF/ventricular tachycardia. The (semi-) automated mode is easy to use, and voice prompts are available to assist its user. However, it has the disadvantage of a hands-off period during the analysis and charge phases. To minimise hands-off time, CPR should continue, at least during the charge phase of the defibrillator.

In the hospital setting, manual mode is generally used by physicians while the (semi-) automated mode is often taught to other healthcare workers (HCWs) and the allied healthcare group. The availability of both alternatives could potentially increase the rate of first responder defibrillation in the hospital. All HCWs should, therefore, be taught and be proficient in how to use an AED or how to defibrillate in a (semi-) automated mode.

NRC recommendations

- All HCWs must know how to use an AED or defibrillate in a (semi-) automated mode with a standard defibrillator.
- Trained personnel may deliver defibrillation in the manual mode.
- Hospital and other clinical establishments should aim at a higher rate of first responder defibrillation. This will involve training of HCW and paramedical personnel in CPR and defibrillation, as well as establishing protocols that allow non-physician-initiated defibrillation in clinical and non-clinical areas.
- All emergency or non-emergency ambulances must be equipped with an AED when transporting patients.

TECHNIQUE OF DEFIBRILLATION

Both self-adhesive pads and paddles are acceptable modes for delivering shocks. When used correctly, they are equally efficacious. The larger the paddle/pad interface, the higher the shock success.[17] Generally, commercially made paddles/pads are about 12 cm in size, a limit that is imposed by the human anatomy.

The paddle/pad must be applied in direct contact with the human skin, and hence, adequate exposure of the application area is essential during the phase of pad application. In an individual with a hairy chest, the area of application should be shaved prior to applying the paddle/pad. In a female patient in an out-of-hospital scenario, chest exposure should be limited to the area where the defibrillation pads are applied, after which the chest wall may be covered by the patient's own clothing. This is to give due respect to women as well as to address concerns that women may not be defibrillated due to the perception that the chest must be fully exposed during the resuscitation.

To maximise the transit of current through the heart, the anterior-lateral position for paddle/pad placement is preferred. The anterior paddle/pad is applied on the right anterior chest just below the right clavicle. The lateral paddle/pad is applied immediately below and lateral to the left nipple. In female patients, the lateral paddle/pad should be applied on the chest wall below and lateral to the left breast, and not over the breast tissue. Alternative acceptable paddle/pad positions include the anterior-posterior and apex-posterior orientations.

In the clinical setting, standard electrode positions of 4-lead cardiac monitoring systems often interfere with proper pad placement for defibrillation as well as other aspects of patient assessment in the course of resuscitation. The recommended positions are described in Box 1.

Box 1. Preferred cardiac monitoring electrode position:

• Right arm lead	Anterior aspect of right shoulder
• Left arm lead	Anterior aspect of left shoulder
• Right leg lead	Right anterior superior iliac spine of pelvis
• Left leg lead	Left anterior superior iliac spine of pelvis
• Ground lead (in 5-lead systems)	Lower end of sternum

NRC recommendations

- Both self-adhesive pads and paddles are acceptable for delivering defibrillation.
- Pads/paddles must be applied in direct contact with the human skin. This requires initial adequate exposure and preparation of the application site. Due respect should be provided to female patients.
- The anterior-lateral orientation is the preferred position for paddle/pad placement. Anterior-posterior and apex-posterior orientations are acceptable alternatives.
- Standardised electrode placement for 4-lead cardiac monitoring systems that does not interfere with paddle/pad placement or other aspects of resuscitation should be adopted.

ICD OR PACEMAKER

Defibrillation has been known to cause malfunction in an implantable cardioverter defibrillator (ICD) or pacemaker. Therefore, care should be taken to ensure that the defibrillation paddle/pad is applied at least four finger breaths away from the device. The anterior-lateral and anterior-posterior positions for paddle/pad placement are acceptable in a patient with a permanent pacemaker or ICD.

NRC recommendation

- In a patient with a permanent pacemaker or ICD, defibrillation paddle/pads should be applied at least four finger breaths away from the device.

USE OF OXYGEN DURING DEFIBRILLATION

The use of oxygen cannot be avoided during resuscitation and poses a small risk of fires. To prevent sparking during attempted defibrillation, efforts should be made to prevent the buildup of an oxygen-enriched environment across the patient's chest. These include:

- Turning off oxygen devices that are not in use.
- Removing any open sources of oxygen (nasal cannula, face mask) and ensuring that any such open sources in use are directed away from the chest.
- Forming a tight seal with the bag-mouth-mask device

when manually ventilating patient or connecting the tracheal tube to a ventilator.

NRC recommendation

- Life support providers must take precautions to minimise sparking during defibrillation.

PROMOTION OF PUBLIC ACCESS DEFIBRILLATION

The 2006 NRC guidelines set out objectives to promote the use of defibrillators among selected groups of personnel and the installation of AEDs in public areas. Much has been done since these NRC recommendations were promulgated. Continual effort is needed to increase the base of first aid providers who could defibrillate. Increased penetration of AED installation and defibrillation programmes is the ongoing objective of NRC. This will be done with additional efforts on the advocacy, implementation, training and educational fronts. Increasing the availability of NRC-accredited CPR+AED courses and the number of quality training centres to run such courses will help to meet these objectives.

NRC recommendations

- In addition to the recommended groups listed in the 2006 guidelines, increased focus will be given to imparting AED skills to the following: student groups (for secondary school levels and above); school teachers; grassroots organisations and community groups; airport workers; all staff of healthcare institutions and medical clinics in public and private practice; staff of commercial and industrial establishments; members of the armed forces; and sports officers and instructors.
- The NRC will also work toward increasing the availability of deployed AEDs in many areas in Singapore—community establishments, public buildings, residential, commercial and industrial areas, work places, sports and entertainment complexes and educational establishments.

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