Guideline 11.4 – Electrical Therapy for Adult Advanced Life Support

Summary

Defibrillation as soon as possible provides the best chance of survival in victims with VF or pulseless VT.

Who does this guideline apply to?

This guideline applies to adults who require advanced life support.

Who is the audience for this guideline?

This guideline is for health professionals and those who provide healthcare in environments where equipment and drugs are available.

Recommendations

The Australian and New Zealand Committee on Resuscitation (ANZCOR) make the following recommendations:

1. A defibrillation shock is delivered as soon as a defibrillator is available.
2. Paddles or pads are placed on the exposed chest in an anterior-lateral position or an anterior-posterior position.
3. In patients with an ICD or a permanent pacemaker the defibrillator pad/paddle is placed on the chest wall ideally at least 8 cm from the generator position.
4. Self-adhesive defibrillation pads are used for defibrillation.
5. Biphasic waveforms are used for defibrillation.
6. For **Monophasic waveforms:** the initial energy level for adults is set at maximum (usually 360 Joules) for all shocks.
7. For **Biphasic waveforms:** the default energy level for adults is set at 200J for all shocks. Other energy levels may be used providing there is relevant clinical data for a specific defibrillator that suggests that an alternative energy level provides adequate shock success (e.g. Usually greater than 90%).
8. If the first shock is not successful and the defibrillator is capable of delivering shocks of higher energy, it is reasonable to increase the energy to the maximum available for

subsequent shocks.

9. A single shock strategy is used in patients in cardiac arrest requiring defibrillation for VF or pulseless VT.
10. The use of AEDs to facilitate early defibrillation in hospitals is reasonable, but services that introduce AEDs must be aware of the possible adverse impact of interruptions to CPR, especially in non-shockable rhythms.

Guideline

A defibrillation shock when applied through the chest produces simultaneous depolarization of a mass of myocardial cells and may enable resumption of organised electrical activity.

1.0 | Indications

A defibrillation shock is indicated for treating Ventricular Fibrillation (VF) and pulseless Ventricular Tachycardia (VT).

2.0 | Timing of Defibrillation

The likelihood of defibrillation success decreases with time until definitive treatment (i.e. defibrillation) is initiated.[5] Interruptions to external cardiac compression (e.g. for rhythm assessment or pulse checks) should be minimised. However, good CPR may even increase the likelihood of defibrillation success.[1] The results of clinical studies assessing the usefulness of a strategy providing a period of CPR before defibrillation rather than a strategy providing immediate defibrillation are not consistent.

In two randomized controlled trials, a period of 1.5 to 3 minutes of CPR by EMS personnel before defibrillation did not improve return of spontaneous circulation (ROSC) or survival to hospital discharge in patients with out-of-hospital VF or pulseless VT, regardless of EMS response interval. One before and after study and another case series failed to demonstrate significant improvements in ROSC or survival to hospital discharge when a strategy of CPR before defibrillation (CPR first) was compared to a shock first strategy. In the Hayakawa study, the CPR first group showed a higher rate of favourable neurologic outcome 30 days and one year after cardiac arrest.

One randomized controlled trial and one clinical trial with historic controls comparing CPR first versus shock first also found no overall difference in outcomes.

However, in both studies, improvements in ROSC, survival to hospital discharge, neurologic outcome and one-year survival were observed in a subgroup of patients who received CPR first where the EMS response interval was greater than 4 to 5 minutes.[2]

Recommendation

ANZCOR suggest delivering a defibrillation shock as soon as a defibrillator is available [Class A; Consensus expert opinion].

3.0 | Positioning of Electrodes

There are no studies in patients with VF/pulseless VT comparing directly the effects of various positions of pad/paddle placement on defibrillation success and ROSC. Most studies evaluate cardioversion (e.g. AF) or secondary endpoints (e.g. transthoracic impedance). Eleven studies found all four positions (anterior-apex, anterior-posterior, anterior-left infrascapular, anterior right-infrascapular) to be equally effective in defibrillation (for VF/pulseless VT) or elective AF cardioversion success.

Four studies support the anterior-posterior position, one study supports the anterior-lateral position and one study supports the anterior-apex position.

Five studies found no effect of electrode position on transthoracic impedance. One study showed that pads/paddles should be placed under the breast tissue and two studies showed that hirsute males should be shaved before to application of pads. Of the 36 studies reviewed, only four examined biphasic waveforms that have gained widespread use.[2]

Recommendation

It is reasonable to place paddles or pads on the exposed chest in an anterior-lateral position. One paddle or pad is placed on the midaxilliary line over the 6th left intercostal space and the other on the right parasternal area over the 2nd intercostal space [Class A; LOE III-2]. Acceptable alternative positions are the anterior-posterior (for paddles and pads) and apex-posterior (for pads). In large-breasted individuals it is reasonable to place the left electrode pad (or paddle) lateral to or underneath the left breast, avoiding breast tissue. Consideration should be given to the rapid removal of excessive chest hair prior to the application of pads/paddles but emphasis must be on minimising delays in shock delivery [2] [Class B; LOE IV].

3.1 | Positioning of electrodes in the presence of a pacemaker/internal defibrillator

Two case series reported pacemaker or implantable cardioverter defibrillator (ICD) malfunction after external defibrillation when the pads were placed in close proximity to the device generator. One small study on atrial cardioversion demonstrated that positioning the pads on the chest at least 8 cm from the device generator did not produce significant damage to pacing sensing and capturing. [2]

Recommendation

In patients with an ICD or a permanent pacemaker, the placement of pad/paddles should not delay defibrillation. When treating an adult with a permanent pacemaker or an implantable

cardioverter defibrillator, the defibrillator pad/paddle should be placed on the chest wall ideally at least 8 cm from the generator position [Class A; LOE IV] .The anterior-posterior and anterior-lateral pad/paddle placements on the chest are acceptable in patients with a permanent pacemaker or ICD [2] [Class B; Extrapolated evidence].

One case report suggested that pacemaker spikes generated by devices programmed to unipolar pacing may confuse AED software and emergency personnel and may prevent the detection of VF.[2]

4.0 | Size of Electrodes

One study has demonstrated that transthoracic impedance decreased and shock success increased with increasing pad size (from 8 to 12 cm). Ten other studies showed that larger pad/paddle sizes (8 to 12 cm diameter) lowered transthoracic impedance and that maximum pad/paddle size was limited by the chest wall size and anatomy. No data related to survival outcome were included in these studies.[2]

There is insufficient evidence to recommend a specific electrode size for optimal external defibrillation in adults. However, it is reasonable to use a pad size >8 cm^2 [Class B; Extrapolated evidence].

5.0 | Paddles / Self Adhesive Pads

Evidence from one small, good quality retrospective control study in 1987 showed that self-adhesive pads were associated with a significantly improved rate of ROSC and hospital admission compared with hand-held paddles. Several studies have shown the practical benefits of pads over paddles for routine monitoring and defibrillation.[2]

One prospective study comparing pads and paddles found lower transthoracic impedance when paddles applied at an optimal force of 8 kg were compared with pads. In a cohort study in patients with atrial fibrillation (AF) the use of hand-held paddles placed in the anterior-posterior position increased the success rate of monophasic cardioversion compared with similarly placed self-adhesive electrodes for monophasic defibrillation. The overall cardioversion success rate for biphasic defibrillators was high (>95%) in all groups. In the majority of other studies, self-adhesive electrodes are associated with similarly high cardioversion success rates.[2]

Recommendation

ANZCOR recommend using self-adhesive defibrillation pads in preference to paddles for defibrillation [Class A; Expert consensus opinion]. They are safe and effective and offer advantages (e.g. facilitating pacing, charging during compressions, safety [including removing risk of fires]) over defibrillation paddles [Class A;LOE III-3, Extrapolated evidence]. If paddles are used, the application of firm pressure and conductive gel pads are recommended for maximum electrical contact. Care should be taken to ensure that pads or electrodes are applied in accordance with manufacturer’s instructions and are not in electrical contact with each other

[Class A; Expert consensus opinion].

The composition of the conductive material of defibrillation electrodes influences transthoracic impedance. In terms of cardiac arrest outcomes, there is insufficient evidence to recommend a specific composition of the defibrillation electrode conductive material.[6]

6.0 | Defibrillation Waveform

In three randomized trials and four other human studies biphasic waveforms had higher shock success rates compared with monophasic defibrillation. Shock success is usually defined as termination of ventricular fibrillation (VF) 5 seconds after the shock.[6] Another randomized study comparing transthoracic incremental monophasic with biphasic defibrillation for out-of-hospital pulseless VT/VF cardiac arrest found no differences in any outcome. A single cohort study using the 2000 International Guidelines demonstrated better hospital discharge and neurologic survival with biphasic than with monophasic waveforms. However, there are confounding factors in that the intervals between the first and second shocks (of three stacked shocks) were shorter with the biphasic defibrillators. There is no clinical evidence for superiority for any specific biphasic waveform over another.[2]

Recommendation

Biphasic waveforms are recommended to be used for defibrillation [Class A; Expert consensus opinion]. There is insufficient evidence to recommend any specific biphasic waveform. In the absence of biphasic defibrillators, monophasic defibrillators are acceptable [Class B; Expert consensus opinion].

7.0 | Energy Levels

7.1 | Biphasic truncated exponential waveform

Evidence from one well-conducted randomised trial and one other human study employing biphasic truncated exponential (BTE) waveforms suggest that higher energy levels are associated with higher shock success rates. In the randomised trial, the first shock success rate was similar with 150 J and 200 J.[2]

7.2 | Biphasic pulsed waveform

In one study using pulsed biphasic waveforms at 130J the first shock success rate was 90%.[2]

7.3 | Rectilinear biphasic waveform

When defibrillation success was defined as ROSC (this differs from the definition used in other studies), one study using a rectilinear biphasic waveform showed that an organised rhythm was restored by the first shock (120 J) in 23% of cases. Success rate for the termination of VF at 5 seconds was not published for this waveform.[2]

7.4 | Monophasic waveform (damped sinusoid or truncated exponential)

Evidence from three studies of monophasic defibrillation suggest equivalent outcomes with lower and higher starting energies.[2]

7.5 | Myocardial damage associated with higher energy level shocks

Several animal studies have suggested the potential for myocardial damage with higher energy shocks using BTE or monophasic waveforms. Human studies involving BTE waveforms have not shown harm as indicated by biomarker levels, ECG findings, and ejection fractions with energy levels up to 360J.[2]

7.6 | Fixed versus escalating energy levels

One randomized trial of 150 J fixed versus 200 J-300 J-360 J shocks and one study (with concurrent controls) of 150 J fixed versus 100 J-150 J-200 J shocks supported the use of an escalating energy biphasic defibrillation protocol compared with a fixed dose defibrillation protocol.

In one study (escalating 200J-200J-360J shocks) the success rate of defibrillation for recurrent VF declined with the number of recurrences. However, these studies were not designed to demonstrate an improvement in the rate of ROSC or survival to hospital discharge.

One study of fixed-dose biphasic defibrillation suggested that defibrillation success improved with three shocks. All of these studies were done with the three shock protocol (before the change in Guidelines 2005).[2]

Recommended Energy Levels

- **Monophasic:** the energy level for adults should be set at maximum (usually 360 Joules) for all shocks. [Class A; LOE III-2][1]

- **Biphasic waveforms:** the default energy level for adults should be set at 200J for all shocks. Other energy levels may be used providing there is relevant clinical data for a specific defibrillator that suggests that an alternative energy level provides adequate shock success (e.g. Usually greater than 90%) [Class A; LOE II]. [2]

ANZCOR suggest if the first shock is not successful and the defibrillator is capable of delivering shocks of higher energy, it is reasonable to increase the energy to the maximum available for subsequent shocks [CoSTR 2015, weak recommendation, very low quality evidence].[3] Escalating shock energy may prevent the risk of refibrillation and is in line with current practices [CoSTR 2015, values and preferences statement].

8.0 | Single Shock Protocol

One study showed no survival benefit from a protocol that included a single shock protocol compared to a three-shock protocol. Evidence from three pre-post design studies suggested significant survival benefit with a single shock defibrillation protocol compared with three stacked shock protocols. However, these studies included confounders related to pre-post design and the multiple interventions that were included as part of the defibrillation protocol. Another pre-post study, with fewer confounding factors, showed a significantly lower hands-off-ratio (ie, percentage of total CPR time when no compressions were provided) with the one-shock protocol but no statistical difference in survival.[2]

One observational study of fixed-dose biphasic defibrillation suggested higher defibrillation success with three shocks. The same paper also suggested that chest compressions immediately following a shock did not result in recurrence of VF. In contrast, another study showed earlier recurrence of VF when chest compressions were resumed immediately after the shock compared with delayed resumption of compressions. There was no difference in total incidence of recurrent VF or outcome. A single study demonstrated early termination of recurrent VF was associated with increased ROSC, but quality of CPR was poor and few patients achieved ROSC. Another study showed decreased survival when defibrillation for recurrent VF was, for a variety of reasons, delayed.[2]

One randomised controlled clinical trial has been published since 2010 comparing single versus stacked shocks and showed no difference in outcome.[7]

Priorities in resuscitation should include early assessment of the need for defibrillation, provision of CPR until a defibrillator is available, and minimization of interruptions in chest compressions. Rescuers can optimize the likelihood of defibrillation success by optimizing the performance of CPR, timing of shock delivery with respect to CPR, and the combination of waveform and energy levels. Rescuers can safely continue CPR while charging a manual defibrillator.[8]

Recommended shock protocol

It is recommended that a single shock strategy be used in patients in cardiac arrest requiring defibrillation for VF or pulseless VT [Class A; Expert consensus opinion]. When using this strategy, CPR should be resumed immediately following shock delivery and interruptions minimised [Class A; LOE IV].

CPR should be continued during charging of the defibrillator, and CPR should not be interrupted

until rhythm reanalysis is undertaken [Class A; Expert consensus opinion].

9.0 | Precautions

Be aware of electrical hazards in the presence of water, metal fixtures, oxygen and flammable substances. Warn of impending discharge by a “stand clear” command.

9.1 | Oxygen and fire risk

Four case reports involving adults and one case report involving a neonate described fires caused by sparks generated during defibrillation attempts when paddles were used in the vicinity of high flow (>10 L/min) oxygen.[2]

In two manikin studies the oxygen concentration in the zone of defibrillation was not increased when ventilation devices (bag-valve device, self-inflating bag, Hamilton Viola ventilator) were left attached to a tracheal tube or when the oxygen source was vented at least 1 meter behind the patient’s mouth. One study described higher oxygen concentrations and longer washout periods when oxygen is administered in confined spaces without adequate ventilation. There are no case reports of fires caused by sparking when shocks were delivered using adhesive pads.[6]

9.2 | Recommended technique

Rescuers should take precautions to minimize sparking (by paying attention to pad/paddle placement, contact, etc) during attempted defibrillation. Rescuers should try to ensure that defibrillation is not attempted in an oxygen-enriched atmosphere (e.g. when high-flow oxygen is directed across the chest) [Class A; Expert consensus opinion].

Rescuers should minimise interruptions to CPR while defibrillating the patient. Rescuers should be able to safely charge a manual defibrillator during CPR when using pads. The defibrillator should be disarmed if a shock is not required [Class B; Expert consensus opinion]. Manual chest compressions should not continue during the delivery of a shock because safety has not been established.

Specifically, rescuers should:

- AVOID charging the paddles unless they are placed on the victim’s chest
- AVOID placing the defibrillator paddles/pads over ECG electrodes (risk of burns or sparks), ECG leads (may melt), medication patches, an implanted device (e.g. a pacemaker), or a central line insertion site
- AVOID having, or allowing any person to have, any direct or indirect contact with the victim during defibrillation (a shock may be received)

- AVOID having the victim in contact with metal fixtures e.g. bed rails (risk of burn)
- AVOID delivering the shock with a gap between the paddle/pad and chest wall (spark hazard)
- AVOID defibrillating if victim, operator and/or close bystander are situated in an explosive/flammable (e.g. petrol) environment
- AVOID allowing oxygen from a resuscitator to flow onto the victim's chest during delivery of the shock when using paddles (risk of fire) [Class A; LOE IV].

10.0 | Confirmation of Shock Delivery

Check that the victim has a muscle response to the shock and there is ECG (electrocardiogram) evidence of shock delivery. If it does not appear that the shock has been delivered, consider that the "synchronise" mode of the defibrillator may be on or there may be a flat battery, lead fracture, charge dump etc.

11.0 | Failure of Defibrillation

If the attempt at defibrillation is unsuccessful:

- Recommence CPR with oxygen (follow algorithm in Guideline 11.2).
- Check paddle or electrode position.
- Check that there is adequate skin contact (clipping or shaving of body hair under the defibrillator paddle/pad may be required).
- Consider changing the defibrillator pads.

12.0 | Use of Automated External Defibrillators (AEDs)

AED use should not be restricted to trained personnel. Allowing use of AEDs by individuals without prior formal training can be beneficial and may be life saving. Since even brief training improves performance (e.g. speed of use, correct pad placement), it is recommended that training in the use of AEDs be provided.

Implementation of AED programs in public settings should be based on the characteristics of published reports of successful programs in similar settings.[9] Services that implement the use of AEDs must be aware of the possible adverse impact of interruptions to CPR, especially in non-shockable rhythms.[4]

Home AED use, for high-risk individuals who do not have an ICD, is safe and feasible and may be considered on an individual basis, but has not been shown to change overall survival rates.[9]

Because population (e.g. rates of witnessed arrest) and program (e.g. response time) characteristics affect survival, when implementing an AED program, community and program leaders should consider factors such as location, development of a team with a responsibility for

monitoring and maintaining the devices, training and retraining programs for those who are likely to use the AED, coordination with the local EMS, and identification of a group of paid or volunteer individuals who are committed to using the AED for victims of arrest.[9]

12.1 | AEDs in manual mode

Modern defibrillators can be operated in both manual and semi-automatic modes. However, few studies compare these two options. One randomized controlled study showed no difference in survival to hospital discharge rate but significant reduction in time to first shock in the AED group versus the manual group (1.1 vs 2.0 minutes). One good concurrent controlled out-of-hospital cardiac arrest study in 36 rural communities showed no improvements in ROSC, survival and neurological outcome but significantly shorter times to first shock and higher VF conversion rates when paramedics used AEDs in semi-automatic mode compared with manual mode. One retrospective study demonstrated no improvement in survival to hospital discharge for in-hospital adult cardiac arrest when comparing AED with manual defibrillators.

In patients with initial asystole or pulseless electrical activity (PEA), AEDs were associated with a significantly lower survival (15%) compared with manual defibrillators (23%, p = 0.04).

In a study of three different EMS systems and one in-hospital center, the manual mode of defibrillation was associated with a lower total hands-off ratio (ie, percentage of total CPR time when no compressions were provided) than AED mode. However, more shocks were delivered inappropriately by rescuers using manual defibrillators (26% manual vs. 6% AEDs). A randomized manikin study simulating cardiac arrest showed a lower hands-off ratio, mainly due to a shorter pre-shock pause, when trained paramedics used the defibrillator in manual mode compared with semi-automatic mode. More inappropriate shocks (12% vs 0), were delivered in manual mode. All episodes of VF were detected and shocked appropriately. A shorter pre-shock pause and lower total hands-off-ratio increase vital organ perfusion and the probability of ROSC.[2]

There are no survival differences between defibrillation in semiautomatic and manual modes during in- and out-of-hospital resuscitation; however, the semi-automatic mode is preferred because it is easier to use and may deliver fewer inappropriate shocks. Trained personnel may deliver defibrillation in manual mode. Use of the manual mode enables chest compressions to be continued during charging, thereby minimizing the pre-shock pause. When using the defibrillator in manual mode, frequent team training and ECG recognition skills are essential.

The defibrillation mode that results in the best outcome will be influenced by the system, and provider skills, training and ECG recognition.[6]

In one in-hospital study, the use of AEDs was not associated with improved survival in those patients with shockable rhythms, but was associated with lower survival in those with non-shockable rhythms.[4]

Recommendation

The use of AEDs is reasonable to facilitate early defibrillation in hospitals [2], but services that introduce AEDs must be aware of the possible adverse impact of interruptions to CPR, especially in non-shockable rhythms [4] [Class B; LOE IV].

13.0 | Use of the Defibrillator for Quality Assurance

13.1 | Data collection

Collection of data from defibrillators enables a comparison of actual performance during cardiac arrests and training events. The results of many observational studies suggest that the rate and depth of external cardiac compressions and ventilation rate were at variance with current guidelines. Monitor/defibrillators modified to enable collection of data on compression rate and depth and ventilation rate may be useful for monitoring and improving process and outcomes after cardiac arrest.[2] However, rescuers should be aware of the potential overestimation of compression depth when the victim is on a soft surface.[10]

13.2 | Waveform analysis

Retrospective analysis of the VF waveform analysis in multiple clinical and animal studies and theoretical models suggest that it is possible to predict the success of defibrillation from the fibrillation waveform with varying reliability. One animal study was neutral.

No human studies have specifically evaluated whether treatment altered by predicting success of defibrillation can improve successful defibrillation, ROSC or survival from cardiac arrest. Multiple waveform parameters have been examined without consensus on the most important parameters to predict outcome.[2]

There is insufficient evidence to support routine use of VF waveform analysis to guide defibrillation management in adult in hospital and out of hospital cardiac arrest.[2] There is insufficient evidence to support or refute the use of artefact filtering algorithms for analysis of ECG rhythm during CPR.[10]

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Referencing this guideline

When citing the ANZCOR Guidelines we recommend:

ANZCOR, 2025, Guideline 11.4 – Electrical Therapy for Adult Advanced Life Support, accessed 22 July 2025, https://www.anzcor.org/home/adult-advanced-life-support/guideline-11-4-electrical-therapy-for-adult-advanced-life-support