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Chapter

AED: Optimal Use of Automated External Defribilators in BLS and ILS

Tudor Ovidiu Popa, Mihaela Corlade-Andrei, Paul Nedelea, Emilian Manolescu, Alexandra Hauta and Diana Cimpoesu

Abstract

The use of Automatic External Defibrillators (AED) present in public access defibrillation programs (PAD) in cardiopulmonary resuscitation (CPR) is a challenge in the effective treatment of cardiac arrest, especially for adult patients. It is already known that the majority of adult cases of out-of-hospital cardiac arrest arise from ventricular fibrillation (VF). The most important factor in determining survival from VF is the time from collapse to defibrillation. If laypersons are trained to perform Basic Life Support (BLS) and to attempt defibrillation using an automatic external defibrillator before the emergency medical services arrive, the survival rate of an out-of-hospital cardiac arrest can be increased. In many countries, the number of public access AEDs has increased but implementation of AED use and CPR performed by public bystanders has not been sufficiently frequent. In fact, only a minority of individuals demonstrate sufficient knowledge and willingness to operate an AED, suggesting that the public is not yet sufficiently prepared. It is also very important to support the permanent campaign of training as many laypersons, starting from school, to properly use such defibrillators in public places. Considering these facts, PAD is an effective way and may be a cost-effective way to improve outcomes in cardiac arrest.

Keywords: automatic external Defibrilator (AED), BLS, ILS, defibrillation, CPR, bystanders, cardiac arrest, education

1. Introduction

Defibrillation is an essential link in the chain of survival in case of ventricular fibrillation (VF) and pulseless ventricular tachycardia (pVT).

For every minute that passes without applying defibrillation, the chance of the patient to respond to this maneuver is decreasing by 7–10%, decreasing also the chance of surviving.

Automated external defibrillators (AEDs) are portable smart life savings devices, designed to administer the necessary treatment for people experiencing sudden cardiac arrest, a medical condition in which the heart stops beating suddenly and unexpectedly when VF or pVT is present.

Public access AEDs can be found in airports, community centers, schools, government buildings, and other crowded public locations. They are intended to be used by lay people who have received minimal or no training.

AEDs are a type of computerized defibrillator that automatically analyzes the heart rhythm in people who are suffering cardiac arrest. When appropriate, it delivers an external electric shock to the heart muscle, the goal being to restore its normal sinusal rhythm.

The combination of cardiopulmonary resuscitation (CPR) and early defibrillation is effective in saving lives when used in the first few minutes following a collapse from sudden cardiac arrest, if the victim presents a cardiac arrest rhythm that requires defibrillation, like ventricular fibrillation or ventricular tachycardia without a pulse.

The AED devices include some accessories, such as pads (electrodes), that are necessary for the AED to detect and interpret a person's heart rhythm and also necessary to deliver an external electric shock if it is needed. There are two main types of AEDs: public access and professional use.

Professional use AEDs are used by first responders, such as emergency medical technicians (EMTs) and paramedics, who receive additional AED training.

Automated defibrillators analyze the heart's rhythm, and if an abnormal heart rhythm is detected, that requires a shock, then the device prompts the user to press a button to deliver a defibrillation shock.

A defibrillator should be used as soon as possible when a person is found in cardiac arrest. CPR should be performed until a defibrillator is brought on the scene.

2. Defibrillation

Defibrillation is an essential link in the chain of survival, in the case of cardiac arrest produced by ventricular fibrillation (VF) and pulseless ventricular tachycardia (pVT). After the onset of cardiac arrest, the circulation is absent and the hypoxic brain injury begins to appear after 3 minutes, if in this interval nobody starts to perform chest compressions.

Defibrillation maneuver can stop cardiac arrest produced by VF/pVT by applying an external electric asynchronous shock, at up to 5 seconds after its application, by depolarizing the myocardium and restoring normal electrical activity, compatible with the presence of a pulse.

Although defibrillation is the most important in the management of patients with shockable rhythms (VF/pVT), also continuous, high quality uninterrupted external chest compressions are required to optimize the chances of successful resuscitation. [1–3]

The success of defibrillation depends on the transmission of the energy to the myocardium and the following conditions are involved:

- The position of the electrodes (pads);
- Transthoracic impedance (depending on the size of the electrodes, the contact between skin and electrodes, contact point pressure, breathing phase);
- Delivered energy;
- Dimensions of the victim's body (body impedance).

In the case of cardiac arrest produced in the pre-hospital, the emergency medical personnel must ensure good quality resuscitation throughout the interval of bringing, applying, and charging the defibrillator. A predetermined duration (for example, two minutes) of CPR before rhythm analysis and shock delivery is no longer recommended, the defibrillator should be used as soon as this is available.

During resuscitation, different types of defibrillators are used depending on the place where the cardiac arrest occurred, the training of the resuscitation team, technical possibilities, and economic resources. [2, 4, 5]

Automatic external defibrillation can be used by bystanders, paramedics, nonmedical personnel, or personnel with medical training who intervene in situations of cardiorespiratory arrest out of the hospital and in some situations in the hospital. Regarding manual defibrillation, this is performed only by medically trained personnel who have the theoretical and practical knowledge necessary to recognize and defibrillate correctly a shockable rhythm. [2, 4, 5]

3. Use of automated external defibrillator

AEDs are safe and effective when used by lay people without or with minimal knowledge of defibrillation.

AEDs make defibrillation possible with many minutes before the arrival of qualified medical help. Resuscitators should focus on voice commands as soon as they begin, especially resuming CPR as soon as possible and minimizing the interruption of chest compressions.

Standard AEDs are suitable for use in children over 8 years of age. Pediatric self-adhesive paddles are used for children between 1 and 8 years old. [1]

The use of the automatic external defibrillator by EMS in the pre-hospital settings.

In the case of out-of-hospital cardiac arrest, the emergency medical personnel must ensure good quality resuscitation during the entire interval of bringing, applying, and loading the defibrillator. For emergency medical services that have implemented a predetermined period of chest compressions before defibrillation, due to the lack of convincing data, it is reasonable for these services to continue this practice. [1, 2]

Below is the guide for using the AED which does not require knowledge of electrocardiography, physiopathology of ventricular fibrillation, or defibrillation energy.

Instead, there is essential knowledge about the device and how to use it, following verbal instructions, knowledge of safety measures in defibrillation, and CPR measures.

The device is equipped with self-adhesive pads, which are placed above the level of the apex of the heart and on the right, subclavicular, or antero-posterior presternal and interscapular.

For patients with implantable medical devices (pacemaker for permanent electrical cardiostimulation, implantable defibrillator), electrodes of defibrillation will be placed at a distance from the device (at least 8 cm) or will use an alternative positioning (antero-lateral, antero-posterior).

Also, the transdermal patches should be removed and cleaned the area before applying the self-adhesive electrodes.

Defibrillation should be performed with minimal interruption of chest compressions (less than 5 seconds, actual recommendation being 3 seconds). Thus, the pause in chest compression can be reduced to less than 5 seconds by continuing chest

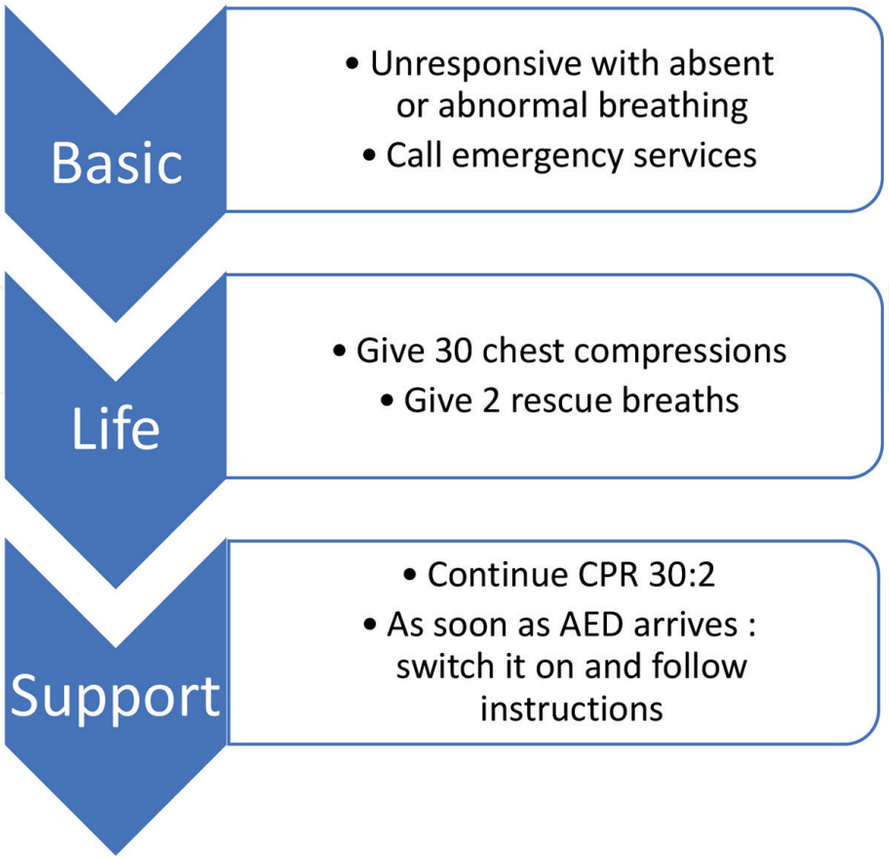

Figure 1.
BLS algorithm. (https://www.cprguidelines.eu/assets/posters/BLS-Algorithms-portrait.pdf).

compressions during charging of the defibrillator and by effective coordination of the resuscitation team, and minimizing pause.

After each schock, immediately resuming chest compressions is extremely important, this strategy should be applied after each shock administration.

In **Figure 1**, we present the BLS and AED algorithm steps from the Basic Life Support algorithm, accordingly to European Resuscitation Council Guideline 2021.

4. Types of energy used in defibrillation

Defibrillation requires the release of sufficient energy to depolarize a critical mass in the myocardium, to stop the chaotic electrical activity and to allow the normal activity of the natural pacemaker to be resumed.

The use of monophasic defibrillators for almost 30 years has brought many benefits, but it also allowed the myocardial injury to be highlighted, produced by the passage of the defibrillation current through the heart.

The monophasic defibrillators, which currently are no longer produced, but continue to be in use, release a unipolar current, which crosses the heart in one direction. There are two types of monophasic current: attenuated sinusoidal current and truncated exponential current.

Modern biphasic defibrillators are designed to deliver a current that crosses the myocardium in both directions: positive and negative. There are also two types of current delivered by this defibrillator: truncated biphasic current and rectilinear biphasic current.

The advantages of biphasic defibrillators are:

- requires less energy for successful defibrillation;
- have smaller capacitors and batteries are smaller;
- they are lighter and more convenient to transport;
- biphasic shocks with energy <200 J have a higher success rate in VF/pVT conversion than 360 J monophasic shocks.

Clinical studies have proven the superiority of defibrillation with defibrillators biphasic, the myocardial injury being minimal, and the efficiency maximal.

5. The automatic external defibrillator

The automatic external defibrillator is a computerized device with the ability to recognize automatically a heart rhythm that requires an external electric shock and to give the indication to apply the external electric shock (in the case of VF/pVT). The sensitivity of the device to recognize a shockable rhythm is very high, AEDs are designed such that they have a very high specificity (>99%) in detecting shockable rhythms.

The device is provided with self-adhesive electrodes (pads), which are placed anteriorly at the apex of the heart and at right, subclavicular position, or antero-posterior (presternal and interscapular, if the situation requires this, for example, wounds present an apex level). To facilitate the positioning of the pads over the chest, on each of them is drawn the place where should be applied.

The presence of a transdermal drug patch on the patient's chest may prevent good contact and may cause electrical arcing and burns if self-adhesive pads are placed over them. Place the pads in an alternative position that avoids the patch or remove the patches and dry the skin area. If an implantable device is present(pacemaker), the pads should be placed at least 8 cm distance.

According to the new recommendations of the Advance Life Support 2021 published by the European Resuscitation Council, defibrillation must be performed with minimal interruption, this should be performed in less than 3 seconds. [2–4]

The protocol for using the automatic/semi-automatic defibrillator:

1. Open the device
2. Connect the device to the patient by applying the self-adhesive electrodes on the patient's chest and attach the electrodes to the device. During steps 1 and 2 perform high-quality chest compressions.
3. Set ANALYSIS mode, and interrupt chest compressions during analysis.
4. Shock. If the rhythm of the cardiac arrest is a shockable VF/pVT, the AED indicates the need to apply the shock and automatically charges 150-360 J. Announce with a loud voice the application of the shock and check that no one is in contact with the patient.

Immediately after applying the external shock, restart CPR (30 chest compressions: 2 ventilations). Repeat these steps after 2 minutes of CPR if VF/pVT is present. [1, 2]

6. Use of AED in the hospital

In every medical facility should be available a defibrillator which can be used in maximum 3 minutes in case of a cardiac arrest occur in a patient. Depending on the partcularityes of each medical facility and the presence of the trained personnel this could be an AED or a manual defibrillator.

There are no published randomized clinical trials comparing the utility of AEDs and manual defibrillators in the hospital. Three observational studies have shown that there is no improvement in the survival of adult patients at discharge following a cardiac arrest when using an AED, compared to a manual defibrillator.

A large observational study showed that in-hospital use of AED was associated with lower survival compared to the one who were defibrillated with a manual defibrillator, suggesting that AED may cause delays in starting CPR or stopping chest compressions in patients with non-shockable rhythm. The goal is to attempt defibrillation within 3 minutes of collapse. [1, 5]

According to the recommendations of the resuscitation guide of the European Council of Resuscitation, up to three successive external electric shocks can be used if ventricular fibrillation/pulseless ventricular tachycardia (VF/VT) occurs during cardiac catheterization or immediately in the postoperative period after cardiac surgery. This three shock strategy can also be considered in case of cardiac arrest assisted by VF/pVT when the patient is already monitored with a manual defibrillator or AED.

Throughout resuscitation and defibrillation, it is important to minimize the duration of the pre- and post-shock pauses, the continuity of chest compressions are recommended during defibrillator charging and rapid resumption of chest compressions after each defibrillation.

During resuscitation, different types of defibrillators are used, depending on multiple factors like the place where the cardiac arrest occurred, the training of the resuscitation team, but also the technical possibilities, the economic resources, and the health programs of each community.

Automated external defibrillation is used by paramedical staff, non-medical, or with medium medical training that intervenes in situations of cardiorespiratory arrest in the prehospital settings, but also in some situations even in the hospital.

In **Table 1**, we present the guidance for using AED:

Stages of use	**Details of operations**
1. Identify cardiac arrest	1. Start CPR Ask someone to bring the nearest defibrillator
2. Open/Start the defibrilator	2. Open the device and follow guidance from the device (spoken or visual) Continue CPR
3. Connecting the device	3. Connect the device to the patient • apply the self-adhesive electrodes on the patient's chest • attach the electrodes to the device Continue CPR

Stages of use	Details of operations
4. Mode setting ANALYZE	4. Analysis • notify the nurse and check if the patient is not in contact with another person • press the ANALYZE button Stop CPR
5. SHOCK	5. Shock delivery0. If FV/pVT is present, the device indicates the need to apply the shock and it automatically charges to 150–360 J. • announce the application of the shock • check again that no one is in contact with the patient • press the SHOCK button after the device is charged. Immediately after applying the shock, resume CPR (30 compressions/2 ventilations). Repeat these steps after 2 min. of CPR as long as VF/pVT is present.

Table 1.
Guidelines for using AED in hospital.

7. Recommendation for semi-automated defibrillator

Semi-automated defibrillators are more complex devices that can be utilized in two modes, as an AED or as a manual defibrillator, depending on the medical personnel.

Manual defibrillation should only be performed by medical personnel, personnel who have the necessary theoretical and practical knowledge in recognition of a shockable rhythm.

Manual defibrillation involves, on the part of the operator:

- Identification of heart rhythm.
- Selection of energy, charging and applying shocks with the indicated energy;
- It can also be used to apply synchronous electric shock (cardioversion).

It is recommended to use self-adhesive electrodes for the defibrillation!
Safety rules:

- Never hold both paddles of the defibrillator in the same hand!
- If the patient is placed on a wet or conductive surface, move the patient to a safe space and dry the patient's chest before delivering the shock!
- Take care that no rescuer accidentally touches directly or indirectly, the patient at the time of shock delivery. Is recommended to use the formula "Attention, I'm defibrillating!"or "Clear!!"!
- Remove the oxygen sources from the defibrillation area (at least 1 meter)!

Defibrillation technique:
A single shock will be applied after every two minutes of resuscitation maneuvers:

- The older models of external defibrillators delivered a monophasic type of waveform. Biphasic defibrillation alternates the direction of the pulses, requires a low level of energy necessary for successful defibrillation, and decreases the risk of myocardial damage.

The first, as well as the following monophasic shocks will be delivered with 360 J;

- In the case of biphasic defibrillators, the first shock will be 150–200 J, the following 200 J, depending on the device up to 360 J;
- The shock will be immediately followed by CPR 30:2 for 2 minutes, without assessment of rhythm or central pulse immediately after administration of the shock. After defibrillation attempts, the majority of patients remain pulseless for at least 2 minutes, even if the defibrillation was successful and restored electrical activity at heart level, the recommendation is to immediately resume chest compressions for 2 minutes following each attempted defibrillation.
- After 2 min. of CPR, if VF/pVT persists, a new one shock will be applied; there is no recommendation for a maximum number of shocks within resuscitation, they will be delivered as long are necessary, if cardiac rhythm assessment performed after 2 minute of CPR identify VF/pVT;
- cardiac rhythm assessment will be done quickly after every 2 minutes of CPR, and evaluation of the central pulse only in the event of the appearance of a rhythm that could suggest the presence of pulse;
- If during the 2 min. of CPR after the shock, appear a rhythm compatible with the presence of spontaneous circulation, chest compressions will not be interrupted unless the victim also presents vital signs like (cough, spontaneous movements);
- If defibrillation restores the patient's circulation and VF/pVT occurs again, defibrillation will be resumed with the energy that was previously successful.

Manual defibrillation protocol:

- VF/pVT is identified on the defibrillator monitor;
- The correct energy level is selected;
- Charge the paddles/pads after they have been applied to the patient's chest;
- People around are warned: "Attention, shock!", "Clear!!";
- Visually check the area;
- The heart rate is checked once again on the monitor;
- The external electric shock is applied;
- Chest compressions and ventilations are initiated immediately, for 2 minutes,

8. Public access defibrillator programs

Regarding all the advantages of using AED in the first moments of cardiac arrest, there is a large consensus for the implementation of public access to defibrillators. Placement of AEDs in areas where a cardiac arrest can be recorded every 5 years is considered cost-effective and comparable to other medical interventions. Registering the AED for public access so the dispatcher can direct the resuscitator to a nearby AED can also help to optimize the response.

The effectiveness of AED use for victims at home is limited. The proportion of patients with FV is lower at home than in public places, however, the number of potential patients who could be treated at home is greater. Public access to defibrillators (PADs) rarely reaches patients at home.

Lay resuscitators performing CPR and directing to an AED can improve the chances of CPR and help reduce the time to defibrillation.

Universal AED Sign ILCOR has designed a simple and clear AED sign that can be recognized worldwide and is recommended to indicate the location of an AED.

Defibrillation programs with public access have the role of improving survival after cardiac arrest if they are established in locations where a cardiac arrest is likely to occur.

Suitable places may include airports, train stations, theaters, and sports facilities. Approximately 80% of prehospital cardiac arrests occur in private or residential settings. This inevitably limits the overall impact that PAD programs can have on survival rates. [2, 5]

AED should be placed in public places (airports, train stations, theaters, stadiums) where there is an increased risk of cardiac arrest occurring with VF/pVT due to the high density of adults and can be used in various technical variants in defibrillation programs for the population—public access defibrillation—PAD.

Within the public programs for defibrillation, ILCOR created a universal sign (**Figure 2**) to indicate the location of an AED, a sign that can be recognized at the international level.

Figure 2.
ILCOR AED sign.

It is indicated that the entity or person who purchases the automatic external defibrillator to inform the emergency medical services about its existence; a physician should supervise it in order to ensure quality control and if there are persons responsible for using the automatic external defibrillator they should be trained on its correct use.

9. The factors that affect the success of defibrillation

Increased chest impedance reduces the level of energy delivered through the heart and decreases the chance of successful defibrillation. This is influenced by the contract between the pads and the skin, by the size of the pads, but also by the breathing phase, impedance being increased during inspiration(inhale) time.

The current recommendations are that the surface of the defibrillation electrode should be at least 150 cm^2, and the diameter should be 8–12 cm. [1, 4, 6, 7]

10. Safety

The defibrillation attempt must be carried out without risk to the members of the resuscitation team. The main risk is represented by the accidentally direct or indirect electrocution of someone of the persons near the victim To minimize this risk, the best solution is to use self-adhesive pads *versus* paddles and by wearing gloves by the members of the medical team. [1, 4, 6]

If an external electrical asynchronous shock is administered to someone who is not in VF or pulseless VT, it is possible some time to be applied exactly during the relative refractory period. If a shock is administered at this vulnerable moment of electric activity of the heart, it is a high chance to induce VF. Because of this, the defibrillation should only be performed for patients who present VF or pulseless VT. [1, 4]

11. Conclusions

Regarding the use of the AED, it is certain that to save a life you need to know minimal things that are very helpful even if you are not a person in the medical field. And if you know from where to bring the defibrillator to the victim, you are still part of the chain of survival because you help the person providing first aid to do his job quickly and save time for the victim's life.

The importance of the interaction between the medical dispatcher, the witness who initiates CPR, including resuscitation maneuvers and timely use of automatic external defibrillator should be stressed.

Essentially, the coordinated community response, which attracts these elements, is essential for improving patient survival, if patient installs cardiorespiratory arrest outside the hospital.

The witness who is trained in Basic Life Support techniques and is available, must assess the victim quickly to determine if the victim is unconscious and not breathing normally, and then to alert the emergency services immediately.

The interaction between the medical dispatcher, the witness initiating CPR and the use of an AED are the essential elements for improving survival in case of cardiac arrest outside the hospital.

The victim who is unresponsive and not breathing normally is in cardiac arrest and requires CPR.

Witnesses and medical dispatchers must suspect cardiac arrest in any patient presenting with seizures and should carefully assess whether the victim breathing normally or not.

Rescuers trained in CPR should combine chest compressions with ventilations.

Conducting high-quality CPR remains essential for the improvement of the results.

Trained rescuers should provide chest compressions with an adequate depth (of at least 5 cm, but not more than 6 cm), with a frequency of 100–120 compressions per min. After each compression allow the chest to return, minimize interruptions during compressions.

When the savior performs breaths/ventilations for 1 second perform insufflation with a sufficient volume to ensure the expansion of the victim's chest.

Chest compression ratio and ventilation is 30:2. Do not stop chest compressions for more than 10 seconds to achieve ventilation.

Defibrillation performed within 3–5 minutes from the debut of cardiac arrest may increase the survival rate by more than 50–70%.

Early defibrillation can be achieved by the rescuer who initiates CPR using the automatic defibrillator external.

AEDs should be implemented in all spaces and public areas where there is a high population density.

We stress again the importance of implementing national programs for Basic Life Support and AED, to give access to defibrillators to the general public population. With these programs, the time from collapse to defibrillation can be greatly reduced.

Conflict of interest

The authors declare no conflict of interest.

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