Equipment Packet: Defibrillator

UMDNS #: 15133

Date of Creation: October 16, 2015

Creator: Engineering World Health (EWH)

Equipment Packet Contents:

This packet contains information about the operation, maintenance, and repair of defibrillators.

Part I: External From the Packet:

Part II: Included in this Packet:

1. Operation and Use of Defibrillators

Featured in this Section:

Malkin, Robert. *Medical Instrumentation in the Developing World*. Engineering World Health, 2006.

WHO. "Defibrillator, External, Automated; Semi-automated." From the publication: *Core Medical Equipment*. Geneva, Switzerland, 2011.

Wikipedia. "Defibrillation." *Wikipedia*, p. 1-12. Retrieved from: https://en.wikipedia.org/wiki/Defibrillation

Wikipedia. "Automated External Defibrillator." *Wikipedia*, p. 1-5. Retrieved from: https://en.wikipedia.org/wiki/Automated_external_defibrillator

Brief Introduction to Defibrillators

Defibrillator, External, Automated; Semiautomated

UMDNS		GMDN	
17116	Defibrillators, External, Automated	48049	Non-rechargeable professional semi-automated external defibrillator
18500	Defibrillators, External, Semiautomated	48048	Rechargeable professional automated external defibrillator

Other common names:
AEDs, automated external defibrillators, automatic external defibrillators, semiautomated defibrillators, and shock-advisory defibrillators, PADs, automated public-access defibrillators

Health problem addressed

Fully automated external defibrillators (AEDs) deliver a high-amplitude current impulse to the heart in order to restore normal rhythm and contractile function in patients who are experiencing ventricular fibrillation (VF) or ventricular tachycardia (VT) that is not accompanied by a palpable pulse.

Product description

AEDs determine whether defibrillation is needed and automatically charge and discharge to deliver a shock. Semiautomated units analyze the ECG and charge in preparation for shock delivery, but the operator activates the discharge. AEDs typically include a memory module or PC data card, disposable adhesive defibrillation electrodes, a display to give status messages (patient and/or defibrillator), to display the ECG waveform, or to prompt the user to initiate a shock.

Principles of operation

Automated defibrillators analyze the ECG rhythm to determine if a defibrillation shock is needed; if it is, the defibrillator warns the operator and automatically charges and discharges. Most of these defibrillators use a single pair of disposable electrodes to monitor the ECG and deliver the defibrillator discharge, but some also incorporate ECG displays. The simple design and ease of use of automated defibrillators requires very little training and operational skill.

Operating steps

The operator attaches two adhesive defibrillator electrodes to the cables or directly to the AED and applies the electrodes to the patient. The AED will automatically analyze the rhythm to determine whether defibrillation is necessary. In fully automatic models, a shock is then automatically delivered when the rhythm analysis determines it is necessary. In semiautomatic units the user is prompted to deliver the shock.

Reported problems

Failure can be caused by defibrillator malfunction, poor electrode application, inappropriate energy selection, a cardiac physiologic state not conducive to defibrillation, or rechargeable battery issues. First- and second-degree burns are especially likely to occur during repeated defibrillation attempts (which require successively higher energies) at the paddle or electrode sites because a high current flow through a small area and/or increased resistance (due to dried gel).

Types and variations

Portable, carrying case

Use and maintenance

User(s): Emergency medical services (EMS), police officers, firefighters, traditional targeted responders (e.g., security guards, flight attendants), nontraditional responders (e.g., office staff, family members), any hospital staff trained in advance life support (ALS) or basic life support (BLS).

Maintenance: Biomedical or clinical engineer/ technician, medical staff, out of hospital (e.g., airlines, shopping centers, emergency medical servicers), manufacturer/servicer

Training: Initial training by manufacturer, operator's manuals, user's guide

Environment of use

Settings of use: Hospital, emergency transport, emergency medical services, patient homes, public building or other public settings

Requirements: Fully charged battery/good battery care and maintenance procedures in place, uninterruptible power source (to power and recharge batteries), proper sized shock pads or electrodes, maintenance procedures to monitor shelf life of shock pads or electrodes, as well as errors returned by internal testing trials.

Product specifications

Approx. dimensions (mm): 100 x 250 x 200

Approx. weight (kg): 2.5

Consumables: Batteries, cables, electrodes/ pads (with gel)

Price range (USD): 1,300 - 2,300

Typical product life time (years): 10

Shelf life (consumables): 1-2 years for disposable electrodes/pads

WHO. "Defibrillator, External, Automated; Semiautomated." From the publication: Core Medical Equipment. Geneva, Switzerland, 2011.

Defibrillator, External, Manual

UMDNS	GMDN
11134 Defibrillators, External, Manual	37806 Manual external defibrillator

Other common names:
Battery-powered defibrillators, cardioverters, defibrillator/monitor/ pacemakers, external biphasic defibrillators, external monophasic defibrillators, and monitor/defibrillators; DC-defibrillator, high-energy (including paddles)

Health problem addressed

Defibrillators are lifesaving devices that apply an electric shock to establish a more normal cardiac rhythm in patients who are experiencing ventricular fibrillation (VF) or another shockable rhythm.

Product description

The defibrillator charges with a large capacitor. For external defibrillation, paddles are needed to discharge on the patient's chest. Disposable defibrillation electrodes may be used as an alternative. For internal defibrillation small concave paddles are used. An ECG monitor included is used to verify a shockable rhythm and the effectiveness of treatment. Many defibrillators can be equipped with optional monitoring capabilities, such as pulse oximetry, end-tidal carbon dioxide and NIBP.

Principles of operation

Defibrillators typically have three basic modes of operation: external defibrillation, internal defibrillation, and synchronized cardioversion. (Sync mode uses a defibrillator discharge to correct certain arrhythmias, such as VT; a shock is delivered only when the control circuits sense the next R wave. The delivery of energy is synchronized with and shortly follows the peak of the R wave, preventing discharge during the vulnerable period of ventricular repolarization.) An audible/visible indicator inform when the capacitor is charged and the device is ready. ECG monitoring can be performed before, during, and after a discharge, usually through ECG electrodes, although most external paddles and disposable electrodes have ECG monitoring capability. Many defibrillators are equipped with optional monitoring capabilities (SpO_2, $ETCO_2$, temperature, NIBP).

Operating steps

Apply the paddles to the patient's chest and discharges the defibrillator. Synchronized cardioversion (sync mode) uses a defibrillator discharge to correct certain arrhythmias, such as VT. After verifying that the sync marker pulse appears reliably on the R wave, the operator presses and holds the paddle discharge buttons; a shock is delivered only when the control circuits sense the next R wave. The delivery of energy is synchronized with and shortly follows the peak of the R wave, preventing discharge during the vulnerable period of ventricular repolarization, which is represented by the T wave.

Reported problems

Failure can be caused by defibrillator malfunction, poor electrode application, inappropriate energy selection, a cardiac physiologic state not conducive to defibrillation, or rechargeable battery issues. First- and second-degree burns are especially likely to occur during repeated defibrillation attempts (which require successively higher energies) at the paddle or electrode sites because a high current flow through a small area and/or increased resistance (due to dried gel).

Use and maintenance

User(s): Physicians, nurses, other medical staff

Maintenance: Biomedical or clinical engineer/ technician, medical staff, manufacturer/ servicer

Training: Initial training by manufacturer, operator's manuals, user's guide

Environment of use

Settings of use: Hospital, emergency transport

Requirements: Fully charged battery/good battery care and maintenance procedures in place, uninterruptible power source (to power and recharge batteries), proper sized shock pads or electrodes, maintenance procedures to monitor shelf life of shock pads or electrodes, as well as errors returned by internal testing trials.

Product specifications

Approx. dimensions (mm): 250 x 300 x 250

Approx. weight (kg): 5.5

Consumables: Batteries, cables, paddles/ electrodes, gel

Price range (USD): 1,000 - 25,000

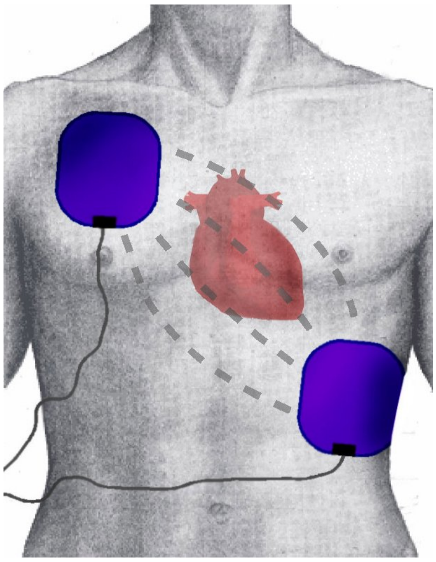
Typical product life time (years): 6-7

Shelf life (consumables): 1-2 years for disposable electrodes/pads

Types and variations

Cart mounted, carry case

Defibrillation


View of defibrillator position and placement, using hands free electrodes.

Defibrillation is the definitive treatment for the life-threatening cardiac arrhythmias, ventricular fibrillation and pulseless ventricular tachycardia. Defibrillation consists of delivering a therapeutic dose of electrical energy to the affected heart with a device called a **defibrillator**. This depolarizes a critical mass of the heart muscle, terminates the arrhythmia, and allows normal sinus rhythm to be reestablished by the body's natural pacemaker, in the sinoatrial node of the heart. Defibrillators can be external, transvenous, or implanted, depending on the type of device used or needed. Some external units, known as automated external defibrillators (AEDs), automate the diagnosis of treatable rhythms, meaning that lay responders or bystanders are able to use them successfully with little, or in some cases no training at all.

History

Defibrillation was first demonstrated in 1899 by Prevost and Batelli, two physiologists from University of Geneva, Switzerland. They discovered that small electric shocks could induce ventricular fibrillation in dogs, and that larger charges would reverse the condition.

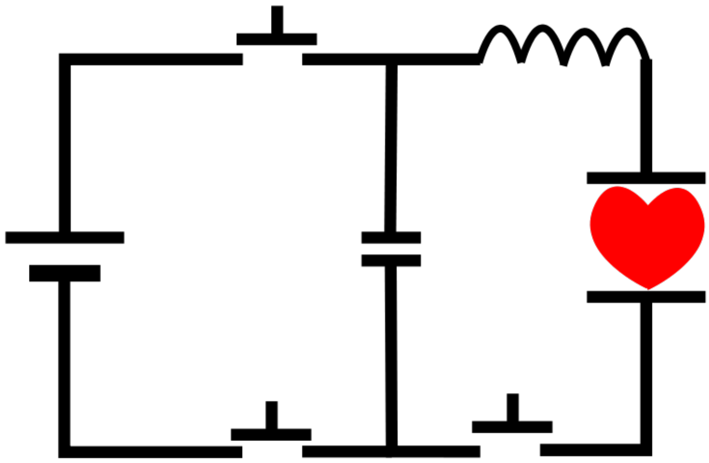
The first use on a human was in 1947 by Claude Beck,[1] professor of surgery at Case Western Reserve University. Beck's theory was that ventricular fibrillation often occurred in hearts which were fundamentally healthy, in his terms "Hearts are too good to die", and that there must be a way of saving them. Beck first used the technique successfully on a 14 year old boy who was being operated on for a congenital chest defect. The boy's chest was surgically opened, and manual cardiac massage was undertaken for 45 minutes until the arrival of the defibrillator. Beck used internal paddles on either side of the heart, along with procainamide, an antiarrhythmic drug, and achieved return of normal sinus rhythm.

These early defibrillators used the alternating current from a power socket, transformed from the 110-240 volts available in the line, up to between 300 and 1000 volts, to the exposed heart by way of 'paddle' type electrodes. The technique was often ineffective in reverting VF while morphological studies showed damage to the cells of the heart muscle post mortem. The nature of the AC machine with a large transformer also made these units very hard to transport, and they tended to be large units on wheels.

Closed-chest method

Until the early 1950s, defibrillation of the heart was possible only when the chest cavity was open during surgery. The technique used an alternating current from a 300 or greater volt source delivered to the sides of the exposed heart by 'paddle' electrodes where each electrode was a flat or slightly concave metal plate of about 40 mm diameter. The closed-chest defibrillator device which applied an alternating current of greater than 1000 volts, conducted by means of externally applied electrodes through the chest cage to the heart, was pioneered by Dr V. Eskin with assistance by A. Klimov in Frunze, USSR (today known as Bishkek, Kyrgyzstan) in mid 1950s.[2]

Move to direct current



A circuit diagram showing the simplest (non-electronically controlled) defibrillator design, depending on the inductor (damping), producing a Lown, Edmark or Gurvich Waveform

In 1959 Bernard Lown commenced research into an alternative technique which involved charging of a bank of capacitors to approximately 1000 volts with an energy content of 100-200 joules then delivering the charge through an inductance such as to produce a heavily damped sinusoidal wave of finite duration (~5 milliseconds) to the heart by way of 'paddle' electrodes. The work of Lown was taken to clinical application by engineer Barouh Berkovits with his "cardioverter".

The Lown waveform, as it was known, was the standard for defibrillation until the late 1980s when numerous studies showed that a biphasic truncated waveform (BTE) was equally efficacious while requiring the delivery of lower levels of energy to produce defibrillation. A side effect was a significant reduction in weight of the machine. The BTE waveform, combined with automatic measurement of transthoracic impedance is the basis for modern defibrillators.

Portable units become available

A major breakthrough was the introduction of portable defibrillators used out of the hospital. This was pioneered in the early 1960s by Prof. Frank Pantridge in Belfast. Today portable defibrillators are among the many very important tools carried by ambulances. They are the only proven way to resuscitate a person who has had a cardiac arrest unwitnessed by EMS who is still in persistent ventricular fibrillation or ventricular tachycardia at the arrival of pre-hospital providers.

Gradual improvements in the design of defibrillators, partly based on the work developing implanted versions (see below), have led to the availability of Automated External Defibrillators. These devices can analyse the heart rhythm by themselves, diagnose the shockable rhythms, and charge to treat. This means that no clinical skill is required in their use, allowing lay people to respond to emergencies effectively.

Change to a biphasic waveform

Until the late 1980s, external defibrillators delivered a Lown type waveform (see Bernard Lown) which was a heavily damped sinusoidal impulse having a mainly uniphasic characteristic. Biphasic defibrillation, however, alternates the direction of the pulses, completing one cycle in approximately 10 milliseconds. Biphasic defibrillation was originally developed and used for implantable cardioverter-defibrillators. When applied to external defibrillators, biphasic defibrillation significantly decreases the energy level necessary for successful defibrillation. This, in turn, decreases risk of burns and myocardial damage.

Ventricular fibrillation (VF) could be returned to normal sinus rhythm in 60% of cardiac arrest patients treated with a single shock from a monophasic defibrillator. Most biphasic defibrillators have a first shock success rate of greater than 90%.[3]

Implantable devices

A further development in defibrillation came with the invention of the implantable device, known as an implantable cardioverter-defibrillator (or ICD). This was pioneered at Sinai Hospital in Baltimore by a team that included Stephen Heilman, Alois Langer, Jack Lattuca, Morton Mower, Michel Mirowski, and Mir Imran, with the help of industrial collaborator Intec Systems of Pittsburgh[4] . Mirowski teamed up with Mower and Staewen, and together they commenced their research in 1969 but it was 11 years before they treated their first patient. Similar developmental work was carried out by Schuder and colleagues at the University of Missouri.

The work was commenced, despite doubts amongst leading experts in the field of arrhythmias and sudden death. There was doubt that their ideas would ever become a clinical reality. In 1962 Bernard Lown introduced the external DC defibrillator. This device applied a direct current from a discharging capacitor through the chest wall into the heart to stop heart fibrillation.[5] In 1972, Lown stated in the journal *Circulation* - "The very rare patient who has frequent bouts of ventricular fibrillation is best treated in a coronary care unit and is better served by an effective antiarrhythmic program or surgical correction of inadequate coronary blood flow or ventricular malfunction. In fact, the implanted defibrillator system represents an imperfect solution in search of a plausible and practical application."[6]

The problems to be overcome were the design of a system which would allow detection of ventricular fibrillation or ventricular tachycardia. Despite the lack of financial backing and grants, they persisted and the first device was implanted in February 1980 at Johns Hopkins Hospital by Dr. Levi Watkins, Jr. Modern ICDs do not require a thoracotomy and possess pacing, cardioversion, and defibrillation capabilities.

The invention of implantable units is invaluable to some regular sufferers of heart problems, although they are generally only given to those people who have already had a cardiac episode.

Types

Manual external defibrillator

External defibrillator / monitor

The units are used in conjunction with (or more often have inbuilt) electrocardiogram readers, which the healthcare provider uses to diagnose a cardiac condition (most often fibrillation or tachycardia although there are some other rhythms which can be treated by different shocks). The healthcare provider will then decide what charge (in joules) to use, based on proven guidelines and experience, and will deliver the shock through paddles or pads on the patient's chest. As they require detailed medical knowledge, these units are generally only found in hospitals and on some ambulances. For instance, every NHS ambulance in the United Kingdom is equipped with a manual defibrillator for use by the attending paramedics and technicians. In the United States, many advanced EMTs and all paramedics are trained to recognize lethal arrhythmias and deliver appropriate electrical therapy with a manual defibrillator when appropriate.

Manual internal defibrillator

These are the direct descendants of the work of Beck and Lown. They are virtually identical to the external version, except that the charge is delivered through internal paddles in direct contact with the heart. These are almost exclusively found in operating theatres, where the chest is likely to be open, or can be opened quickly by a surgeon.

Automated external defibrillator (AED)

These simple-to-use units are based on computer technology which is designed to analyze the heart rhythm itself, and then advise the user whether a shock is required. They are designed to be used by lay persons, who require little training to operate them correctly. They are usually limited in their interventions to delivering high joule shocks for VF (ventricular fibrillation) and VT (ventricular tachycardia) rhythms, making them generally of limited use to health professionals, who could diagnose and treat a wider range of problems with a manual or semi-automatic unit.

An AED at a railway station in Japan. The AED box has information on how to use it in Japanese, English, Chinese and Korean, and station staff are trained to use it.

The automatic units also take time (generally 10–20 seconds) to diagnose the rhythm, where a professional could diagnose and treat the condition far more quickly with a manual unit.[7] These time intervals for analysis, which require stopping chest compressions, have been shown in a number of studies to have a significant negative effect on shock success.[8] This effect led to the recent change in the AHA defibrillation guideline (calling for two minutes of CPR after each shock without analyzing the cardiac rhythm) and some bodies recommend that AEDs should not be used when manual defibrillators and trained operators are available.[7]

Automated external defibrillators are generally either held by trained personnel who will attend incidents, or are **public access** units which can be found in places including corporate and government offices, shopping centres, airports, restaurants, casinos, hotels, sports stadiums, schools and universities, community centers, fitness centers and health clubs.

An automated external defibrillator, open and ready for pads to be attached

The locating of a public access AED should take in to account where large groups of people gather, and the risk category associated with these people, to ascertain whether the risk of a sudden cardiac arrest incident is high. For example, a center for teenage children is a particularly low risk category (as children very rarely enter heart rhythms such as VF (Ventricular Fibrillation) or VT (Ventricular Tachycardia), being generally young and fit, and the most common causes of pediatric cardiac arrest are respiratory arrest and trauma - where the heart is more likely to enter asystole or PEA, (where an AED is of no use). On the other hand, a large office building with a high ratio of males over 50 is a very high risk environment.

In many areas, emergency services vehicles are likely to carry AEDs. EMT-Basics in most areas are not trained in manual defibrillation, and often carry an AED instead. Some ambulances carry an AED in addition to a manual unit. In addition, some police or fire service vehicles carry an AED for first responder use. Some areas have dedicated community first responders, who are volunteers tasked with keeping an AED and taking it to any victims in their area. It is also increasingly common to find AEDs on transport such as commercial airlines and cruise ships. The presence of an AED can be a particularly decisive factor in cardiac patient survival in these scenarios, as professional medical assistance may be hours away.

In order to make them highly visible, public access AEDs often are brightly coloured, and are mounted in protective cases near the entrance of a building. When these protective cases are opened, and the defibrillator removed, some will sound a buzzer to alert nearby staff to their removal but do not necessarily summon emergency services. All trained AED operators should also know to phone for an ambulance when sending for or using an AED, as the patient will be unconscious, which always requires ambulance attendance.

Semi-automated external defibrillators

. These units are a compromise between a full manual unit and an automated unit. They are mostly used by pre-hospital care professionals such as paramedics and emergency medical technicians. These units have the automated capabilities of the AED but also feature an ECG display, and a manual override, where the clinician can make their own decision, either before or instead of the computer. Some of these units are also able to act as a pacemaker if the heart rate is too slow (bradycardia) and perform other functions which require a skilled operator.

A Lifepak semi-automatic defibrillator/ECG monitor mounted in an ambulance. These units are designed for use only by healthcare professionals and are capable of measuring blood pressure and blood oxygen saturation in addition to the primary functions

Implantable cardioverter-defibrillator (ICD)

Also known as automatic internal cardiac defibrillator (AICD). These devices are implants, similar to pacemakers (and many can also perform the pacemaking function). They constantly monitor the patient's heart rhythm, and automatically administer shocks for various life threatening arrhythmias, according to the device's programming. Many modern devices can distinguish between ventricular fibrillation, ventricular tachycardia, and more benign arrhythmias like supraventricular tachycardia and atrial fibrillation. Some devices may attempt overdrive pacing prior to synchronised cardioversion. When the life threatening arrhythmia is ventricular fibrillation, the device is programmed to proceed immediately to an unsynchronized shock.

There are cases where the patient's ICD may fire constantly or inappropriately. This is considered a medical emergency, as it depletes the device's battery life, causes significant discomfort and anxiety to the patient, and in some cases may actually trigger life threatening arrhythmias. Some emergency medical services personnel are now equipped with a ring magnet to place over the device, which effectively disables the shock function of the device while still allowing the pacemaker to function (if the device is so equipped). If the device is shocking frequently, but appropriately, EMS personnel may administer sedation.

Wearable cardiac defibrillator

A development of the AICD is a portable external defibrillator that is worn like a vest.[9] The unit monitors the patient 24 hours a day and will automatically deliver a biphasic shock if needed. This device is mainly indicated in patients awaiting an implantable defibrillator. Currently only one company manufactures these and they are of limited availability.

Modelling defibrillation

The efficacy of a cardiac defibrillator is highly dependent on the position of its electrodes. Most internal defibrillators are implanted in octogenarians, but a few children need the devices. Implanting defibrillators in kids is particularly difficult because children are small, will grow over time, and possess cardiac anatomy that differs from that of adults. Recently, researchers were able to create a software modeling system capable of mapping an individual’s thorax and determining the optimal position for an external or internal cardiac defibrillator.

With the help of pre-existing surgical planning applications, the software uses myocardial voltage gradients to predict the likelihood of successful defibrillation. According to the critical mass hypothesis, defibrillation is effective only if it produces a threshold voltage gradient in a large fraction of the myocardial mass. Usually, a gradient of three to five volts per centimeter is needed in 95 % of the heart. Voltage gradients of over 60 V/cm can damage tissue. The modeling software seeks to obtain safe voltage gradients above the defibrillation threshold.

Early simulations using the software suggest that small changes in electrode positioning can have large effects on defibrillation, and despite engineering hurdles that remain, the modeling system promises to help guide the placement of implanted defibrillators in children and adults.

Recent mathematical models of defibrillation are based on the bidomain model of cardiac tissue. [10] Calculations using a realistic heart shape and fiber geometry are required to determine how cardiac tissue responds to a strong electrical shock.

Interface with the patient

The most well-known type of electrode (widely depicted in films and television) is the traditional metal paddle with an insulated (usually plastic) handle. This type must be held in place on the patient's skin while a shock or a series of shocks is delivered. Before the paddle is used, a gel must be applied to the patient's skin, in order to ensure a good connection and to minimize electrical resistance, also called chest impedance (despite the DC discharge). These are generally only found on the manual external units.

Newer types of resuscitation electrodes are designed as an adhesive pad. These are peeled off their backing and applied to the patient's chest when deemed necessary, much the same as any other sticker. These electrodes are then connected to a defibrillator. If defibrillation is required, the machine is charged, and the shock is delivered, without any need to apply any gel or to retrieve and place any paddles. These adhesive pads are found on most automated and semi-automated units, and are gradually replacing paddles entirely in non-hospital settings.

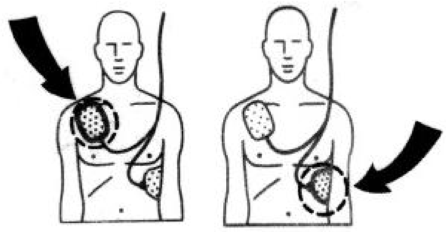
Both solid- and wet-gel adhesive electrodes are available. Solid-gel electrodes are more convenient, because there is no need to clean the patient's skin after removing the electrodes. However, the use of solid-gel electrodes presents a higher risk of burns during defibrillation, since wet-gel electrodes more evenly conduct electricity into the body.

Some adhesive electrodes are designed to be used not only for defibrillation, but also for transcutaneous pacing and synchronized electrical cardioversion.

In a hospital setting, paddles are generally preferred to pads, due to the inherent speed with which they can be placed and used. This is critical during cardiac arrest, as each second of nonperfusion means tissue loss. However, in cases in which cardiac arrest is suspected, patches placed prophalacticaly are superior,as they provide appropriate EKG tracing without the artifact visible from human interference with the paddles. Adhesive electrodes are also inherently safer than the paddles for the operator of the defibrillator to use, as they minimize the risk of the operator coming into physical (and thus electrical) contact with the patient as the shock is delivered, by allowing the operator to stand several feet away. Adhesive patches also require no force to remain in place and deliver the shock appropriately, whereas paddles require approximately 25 lbs of force to be applied while the shock is delivered.[Citation Needed]

Placement

Resuscitation electrodes are placed according to one of two schemes. The anterior-posterior scheme (conf. image) is the preferred scheme for long-term electrode placement. One electrode is placed over the left precordium (the lower part of the chest, in front of the heart). The other electrode is placed on the back, behind the heart in the region between the scapula. This placement is preferred because it is best for non-invasive pacing.



Anterio-apical placement of external defibrillator electrodes (When defibrillation is unsuccessful, anterior-posterior placement is also sometimes attempted)

The anterior-apex scheme can be used when the anterior-posterior scheme is inconvenient or unnecessary. In this scheme, the anterior electrode is placed on the right, below the clavicle. The apex electrode is applied to the left side of the patient, just below and to the left of the pectoral muscle. This scheme works well for defibrillation and cardioversion, as well as for monitoring an ECG.

Popular culture references

As devices that can quickly produce dramatic improvements in patient health, defibrillators are often depicted in movies and television. Their function, however, is often exaggerated, with the defibrillator inducing a sudden, violent jerk or convulsion by the patient; in reality, although the muscles may contract, such dramatic patient presentation is rare. Similarly, medical providers are often depicted defibrillating patients with a "flat-line" ECG rhythm (also known as asystole); this is not done in real life. Only the cardiac arrest rhythms ventricular fibrillation and pulseless ventricular tachycardia are normally defibrillated. (There are also several heart rhythms that can be "shocked" when the patient is not in cardiac arrest, such as supraventricular tachycardia and ventricular tachycardia that produces a pulse; this procedure is known as cardioversion, not defibrillation.)

In Australia up until the 1990s it was quite rare for ambulances to carry defibrillators. This changed in 1990 after Australian media mogul Kerry Packer had a heart attack and, purely by chance, the ambulance that responded to the call carried a defibrillator. After recovering, Kerry Packer donated a large sum to the Ambulance Service of New South Wales in order that all ambulances in New South Wales should be fitted with a personal defibrillator, which is why defibrillators in Australia are colloquially called "Packer Whackers".[11]

See also

- Cardiopulmonary resuscitation (CPR)
- Advanced cardiac life support (ACLS)
- Cardioversion
- Automated external defibrillator
- Myocardial infarction (heart attack)
- Ambulance
- Wearable Cardioverter Defibrillator

References

[1] "Claude Beck, defibrillation and CPR" (http://www.case.edu/artsci/dittrick/site2/museum/artifacts/group-c/c-8defrib.htm). Case Western Reserve University. . Retrieved 2007-06-15.

[2] Sov Zdravookhr Kirg.. "Some results with the use of the DPA-3 defibrillator (developed by V. Ia. Eskin and A. M. Klimov) in the treatment of terminal states" (http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&list_uids=5880446&dopt=Abstract) (in Russian). . Retrieved 2007-08-26.

[3] Heart Smarter: EMS Implications of the 2005 AHA Guidelines for ECC & CPR (http://www.jems.com/data/pdf/AHA_Supplement.pdf) pp 15-16

[4] http://www3.interscience.wiley.com/journal/118913850/abstract?CRETRY=1&SRETRY=0

[5] Aston, Richard (1991). *Principles of Biomedical Instrumentation and Measurement: International Edition*. Merrill Publishing Company. ISBN 0-02-946562-1.

[6] "Pacemaker Failure following External Defibrillation" (http://circ.ahajournals.org/cgi/reprint/45/5/1144-a.pdf). *Circulation: Journal of the American Heart Association*. 1972. ISSN 1524-4539. .

[7] editors Jasmeet Soar ...; Soar, J; Nolan, J;Perkins, G; Scott, M;Goodman, N;Mitchell, S (2006). *Immediate Life Support: Second Edition*. Resuscitation Council (UK). ISBN 1-903812-12-7.

[8] Eftestol T, Sunde K, Steen PA. Effects of interrupting precordial compressions on the calculated probability of defibrillation success during out-of-hospital cardiac arrest. *Circulation* 2002;105:2270-3

[9] "What is the LifeVest?" (http://www.zoll.lifecor.com/about_lifevest/about.asp). Zoll Lifecor. . Retrieved 2009-02-09.

[10] Trayanova N (2006). "Defibrillation of the heart: insights into mechanisms from modelling studies". *Experimental Physiology* **91** (2): 323–337. doi:10.1113/expphysiol.2005.030973. PMID 16469820.

[11] "Defibrillation" (http://medical-dictionary.thefreedictionary.com/Packer+Whacker). Farlex, Inc.. . Retrieved 2009-04-21.

- Picard, André (2007-04-27). "School defibrillators could be lifesavers" (http://www.theglobeandmail.com/servlet/story/RTGAM.20070427.wxldefib27/BNStory/specialScienceandHealth/home). *The Globe and Mail*. Retrieved 2008-06-20.

External links

- Sudden Cardiac Arrest Foundation (http://www.sca-aware.org/)
- Center for Integration of Medicine and Innovative Technology (http://www.cimit.org)
- American Red Cross: Saving a Life is as Easy as A-E-D (http://www.redcross.org/services/hss/courses/aed.html)
- FDA Heart Health Online: Automated External Defibrillator (AED) (http://www.fda.gov/hearthealth/treatments/medicaldevices/aed.html)
- Resuscitation Council (UK) (http://www.resus.org.uk)
- History of defibrillation (http://efimov.wustl.edu/defibrillation/history/defibrillation_history.htm)
- How an internal defibrillator is implanted (http://heartcenter.seattlechildrens.org/what_to_expect/pacemakers.asp) from Children's Hospital Heart Center, Seattle.

Article Sources and Contributors

Defibrillation *Source*: http://en.wikipedia.org/w/index.php?oldid=359342620 *Contributors*: 1337pino, Aatrek, Adw2000, Alansohn, AnnaFrance, Aruton, Badger151, Bongwarrior, Bradjamesbrown, Bricaniwi, C3o, CambridgeBayWeather, Cburnett, Cimiteducation, Clarince63, Coralmizu, Countincr, Cygnosis, DefibrillatorHub, Delldude101, Discospinster, Dj stone, Djinn112, Dnvrfantj, Dokane, Donfbreed, Dycedarg, Eastmain, Eh-Steve, Ehudzel, Emperorbma, Esperant, Firsfron, Footwarrior, Furrykef, Gene Nygaard, Geoffrey Wickham, Gilo1969, Gnusmas, Heggyhomolit, Hehkuviini, Hugh2414, Iefimov, Infralap, Iridescent, J.delanoy, Jaapinwiki, Jackliddle, Jastewart, JessicaK15, Jet731, Jfdwolff, Joel7687, John Hill, Johnpnagy, Jovianeye, Jpmizell, Kakofonous, Kchishol1970, Keilana, Kingturtle, Kitch, Kkailas, Ksheka, Kylu, LandruBek, Largoplazo, Lattucak, Lc3i, Lolmaster, Londonsista, Lwg9q, Lynbarn, Maximillion Pegasus, Medicellis, Mi28, Michael Devore, Mikr18, Mild Bill Hiccup, Mnokel, Modster, Montrealais, MoodyGroove, Moscvitch, ObtuseMarginal, Owain.davies, Oxymoron83, Pakaraki, Piano non troppo, Pixeltoo, Rama, Ravik, Rhezalouis, Richardcavell, Rjwilmsi, Rorynic, Rothbrad, RoyBoy, Rsabbatini, Sassf, Scottalter, Sdumont, Sfcollegeguy, Sgpsaros, SiobhanHansa, SkyWalker, Snalwibma, Snorks1234, Snoyes, Someone else, Spitfire, Spra, Squiggle, Stadler981, Stare at the sun, Sumthingweird, SuperHamster, SwissArmyLight, TUF-KAT, Tabuhan, Terra Green, Thumperward, Tjwood, TofuMatt, Trainspotter, Trevor Johns, Tristanb, UniQue tree, Uruiamme, Vegaswikian, Walden, WhyBeNormal, Wik, Wolfmankurd, Wouterstomp, Xiner, Xkcd, Zephyrad, Zhang He, 225 anonymous edits

Image Sources, Licenses and Contributors

Image:Defibrillation Electrode Position.jpg *Source*: http://en.wikipedia.org/w/index.php?title=File:Defibrillation_Electrode_Position.jpg *License*: Creative Commons Attribution-Sharealike 3.0 *Contributors*: PhilippN

Image:Defrib.svg *Source*: http://en.wikipedia.org/w/index.php?title=File:Defrib.svg *License*: GNU Free Documentation License *Contributors*: Original uploader was Wolfmankurd at en.wikipedia

Image:Defibrillator Monitor.jpg *Source*: http://en.wikipedia.org/w/index.php?title=File:Defibrillator_Monitor.jpg *License*: Creative Commons Attribution-Sharealike 2.5 *Contributors*: User:Ernstl

Image:AED Oimachi 06z1399sv.jpg *Source*: http://en.wikipedia.org/w/index.php?title=File:AED_Oimachi_06z1399sv.jpg *License*: BSD *Contributors*: User:Cory

Image:AED Open.jpg *Source*: http://en.wikipedia.org/w/index.php?title=File:AED_Open.jpg *License*: Public Domain *Contributors*: User:Owain.davies

Image:lifepak.JPG *Source*: http://en.wikipedia.org/w/index.php?title=File:Lifepak.JPG *License*: GNU Free Documentation License *Contributors*: User:Heggyhomolit

Image:Defib electrode placement.JPG *Source*: http://en.wikipedia.org/w/index.php?title=File:Defib_electrode_placement.JPG *License*: GNU Free Documentation License *Contributors*: Andersat, Glenn, Staph, Stevenfruitsmaak, 3 anonymous edits

License

Automated external defibrillator

An **automated external defibrillator** or **AED** is a portable electronic device that automatically diagnoses the potentially life threatening cardiac arrhythmias of ventricular fibrillation and ventricular tachycardia in a patient,[1] and is able to treat them through defibrillation, the application of electrical therapy which stops the arrhythmia, allowing the heart to reestablish an effective rhythm.

An automated external defibrillator, open and ready for pads to be attached

AEDs are designed to be simple to use for the layman, and the use of AEDs is taught in many first aid, first responder and basic life support (BLS) level CPR classes.[2]

Usage

Conditions that the Device Treats

An automated external defibrillator is used in cases of life threatening cardiac arrhythmias which lead to cardiac arrest. The rhythms that the device will treat are usually limited to:

1. Pulseless Ventricular tachycardia (shortened to VT or V-Tach)[1]
2. Ventricular fibrillation (shortened to VF or V-Fib)

In each of these two types of shockable cardiac arrhythmia, the heart is active, but in a life-threatening, dysfunctional pattern. In ventricular tachycardia, the heart beats too fast to effectively pump blood. Ultimately, ventricular tachycardia leads to ventricular fibrillation. In ventricular fibrillation, the electrical activity of the heart becomes chaotic, preventing the ventricle from effectively pumping blood. The fibrillation in the heart decreases over time, and will eventually reach asystole.

AEDs, like all defibrillators, are not designed to shock asystole ('flat line' patterns) as this will not have a positive clinical outcome. The asystolic patient only has a chance of survival if, through a combination of CPR and cardiac stimulant drugs, one of the shockable rhythms can be established, which makes it imperative for CPR to be carried out prior to the arrival of a defibrillator.

Effect of Delayed Treatment

Uncorrected, these cardiac conditions (ventricular tachycardia, ventricular fibrillation, asystole) rapidly lead to irreversible brain damage and death. After approximately three to five minutes,[3] irreversible brain/tissue damage may begin to occur. For every minute that a person in cardiac arrest goes without being successfully treated (by defibrillation), the chance of survival decreases by 10 percent.[4]

Requirements for Use

AEDs are designed to be used by laypersons who ideally should have received AED training. This is in contrast to more sophisticated manual and semi-automatic defibrillators used by health professionals, which can act as a pacemaker if the heart rate is too slow (bradycardia) and perform other functions which require a skilled operator able to read electrocardiograms.

Bras with a metal underwire and piercings on the torso must be removed before using the AED on someone to avoid interference.[5]

A study analyzed the effects of having AEDs immediately present during Chicago's Heart Start program over a two year period. Of 22 individuals 18 were in a cardiac arrhythmia which AEDs can treat (Vfib or Vtach). Of these 18, 11 survived. More interestingly, of these 11 patients, 6 were treated by good Samaritan bystanders with absolutely no previous training in AED use.[6] [7]

Placement and Availability

Automated external defibrillators are generally either held by trained personnel who will attend events or are public access units which can be found in places including corporate and government offices, shopping centres, airports, restaurants, casinos, hotels, sports stadiums, schools and universities, community centers, fitness centers, health clubs, workplaces and any other location where people may congregate.

An AED at a railway station in Japan.

The location of a public access AED should take in to account where large groups of people gather, regardless of age or activity. Children as well as adults may fall victim to sudden cardiac arrest (SCA)

In many areas, emergency vehicles are likely to carry AEDs, with some ambulances carrying an AED in addition to manual defibrillators. Police or fire vehicles often carry an AED for first responder use. Some areas have dedicated community first responders, who are volunteers tasked with keeping an AED and taking it to any victims in their area. AEDs are also increasingly common on commercial airlines, cruise ships, and other transportation facilities.

In order to make them highly visible, public access AEDs often are brightly colored, and are mounted in protective cases near the entrance of a building. When these protective cases are opened or the defibrillator is removed, some will sound a buzzer to alert nearby staff to their removal, though this does not necessarily summon emergency services; trained AED operators should know to phone for an ambulance when sending for or using an AED. In September 2008, the International Liaison Committee on Resuscitation issued a 'universal AED sign' to be adopted throughout the world to indicate the presence of an AED, and this is shown at right.[8]

A trend that is developing is the purchase of AEDs to be used in the home, particularly by those with known existing heart conditions.[9] The number of devices in the community has grown as prices have fallen to affordable levels. There has been some concern among medical professionals that these home users do not necessarily have appropriate training,[10] and many advocate the more widespread use of community responders, who can be appropriately trained and managed.

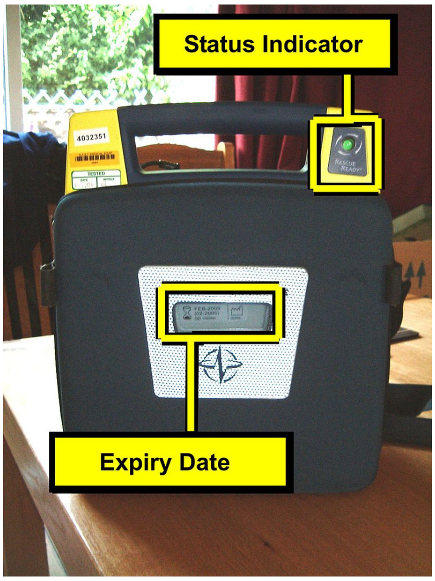
Typically, an AED kit will contain a face shield for providing a barrier between patient and first aider during rescue breathing; a pair of nitrile rubber gloves; a pair of trauma shears for cutting through a patient's clothing to expose the chest; a small towel for wiping away any moisture on the chest, and a razor for shaving those with very hairy chests.[11]

Preparation for operation

Most manufacturers recommend checking the AED before every period of duty or on a regular basis for fixed units. Some units need to be switched on in order to perform a self check; other models have a self check system built in with a visible indicator.

All manufacturers mark their pads with an expiry date, and it is important to ensure that the pads are in date. This is usually marked on the outside of the pads. Some models are designed to make this date visible through a 'window', although others will require the opening of the case to find the date stamp.

Mechanism of operation



The use of easily visible status indicator and pad expiration date on one model of AED

An AED is *external* because the operator applies the electrode pads to the bare chest of the victim, as opposed to internal defibrillators, which have electrodes surgically implanted inside the body of a patient.

Automatic refers to the unit's ability to autonomously analyse the patient's condition, and to assist this, the vast majority of units have spoken prompts, and some may also have visual displays to instruct the user.

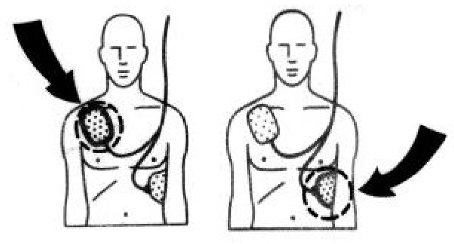
When turned on or opened, the AED will instruct the user to connect the electrodes (pads) to the patient. Once the pads are attached, everyone should avoid touching the patient so as to avoid false readings by the unit. The pads allow the AED to examine the electrical output from the heart and determine if the patient is in a shockable rhythm (either ventricular fibrillation or ventricular tachycardia). If the device determines that a shock is warranted, it will use the battery to charge its internal capacitor in preparation to deliver the shock. This system is not only safer (charging only when required), but also allows for a faster delivery of the electrical current.

When charged, the device instructs the user to ensure no one is touching the patient and then to press a button to deliver the shock; human intervention is usually required to deliver the shock to the patient in order to avoid the possibility of accidental injury to another person (which can result from a responder or bystander touching the patient at the time of the shock). Depending on the manufacturer and particular model, after the shock is delivered most devices will analyze the patient and either instruct CPR to be given, or administer another shock.

Many AED units have an 'event memory' which store the ECG of the patient along with details of the time the unit was activated and the number and strength of any shocks delivered. Some units also have voice recording abilities to monitor the actions taken by the personnel in order to ascertain if these had any impact on the survival outcome. All this recorded data can be either downloaded to a computer or printed out so that the providing organisation or responsible body is able to see the effectiveness of both CPR and defibrillation.

The first commercially available AEDs were all of a monophasic type, which gave a high-energy shock, up to 360 to 400 joules depending on the model. This caused increased cardiac injury and in some cases second and third-degree burns around the shock pad sites. Newer AEDs (manufactured after late 2003) have tended to utilise biphasic algorithms which give two sequential lower-energy shocks of 120 - 200 joules, with each shock moving in an opposite polarity between the pads. This lower-energy waveform has proven more effective in clinical tests, as well as offering a reduced rate of complications and reduced recovery time.[12]

Simplicity of use



Usual placement of pads on chest

Unlike regular defibrillators, an automated external defibrillator requires minimal training to use. It automatically diagnoses the heart rhythm and determines if a shock is needed. Automatic models will administer the shock without the user's command. Semi-automatic models will tell the user that a shock is needed, but the user must tell the machine to do so, usually by pressing a button. In most circumstances, the user cannot override a "no shock" advisory by an AED. Some AEDs may be used on children - those under 55 lbs (25 kg) in weight or under age 8. If a particular model of AED is approved for pediatric use, all that is required is the use of more appropriate pads. Some organizations, such as the American Heart Association, recommend that if pediatric AED pads are not available, adult pads should be used to determine if the child is in a shockable rhythm. There is insufficient evidence to suggest that a child, in a shockable cardiac arrest, can be "hurt" by an adult defibrillation energy setting.

All AEDs approved for use in the United States use an electronic voice to prompt users through each step. Because the user of an AED may be hearing impaired, many AEDs now include visual prompts as well. Most units are designed for use by non-medical operators. Their ease of use has given rise to the notion of public access defibrillation (PAD), which experts agree has the potential to be the single greatest advance in the treatment of out-of-hospital cardiac arrest since the invention of CPR.[13]

Liability

Automated external defibrillators are now easy enough to use that most states in the United States include the "good faith" use of an AED by any person under the Good Samaritan laws.[14] "Good faith" protection under a Good Samaritan law means that a volunteer responder (not acting as a part of one's occupation) cannot be held civilly liable for the harm or death of a victim by providing improper or inadequate care, given that the harm or death was not intentional and the responder was acting within the limits of their training and in good faith. In the United States, Good Samaritan laws provide some protection for the use of AEDs by trained and untrained responders.[15] AEDs create little liability if used correctly;[16] NREMT-B and many state EMT training and many CPR classes incorporate or offer AED education as a part of their program. In addition to Good Samaritan laws, Ontario, Canada also has the "Chase McEachern Act (Heart Defibrillator Civil Liability), 2007 (Bill 171 – Subsection N)", passed in June, 2007,[17] which protects individuals from liability for damages that may occur from their use of an AED to save someone's life at the immediate scene of an emergency unless damages are caused by gross negligence.

External links

- American Heart Association: Learn & Live [18]
- American Red Cross: Saving a Life is as Easy as A-E-D [19]
- FDA Heart Health Online: Automated External Defibrillator (AED) [20]
- Resuscitation Council (UK) [21]

References

[1] Kerber, Richard E; Becker, Lance B; Bourland, Joseph D; Cummins, Richard O; Hallstrom, Alfred P; Michos, Mary B; Nichol, Graham; Ornato, Joseph P; Thies, William H; White, Roger D; Zuckerman, Bram D (March 18, 1997). "Automatic External Defibrillators for Public Access Defibrillation" (http://circ.ahajournals.org/cgi/content/full/95/6/1677). *Circulation* (American Heart Association) **95** (1677-1682): 1677. PMID 9118556. . Retrieved 2007-06-28.

[2] "CPR Adult Courses" (http://www.redcross.org/services/hss/courses/adultcpraed.html). American Red Cross. . Retrieved 2007-06-28.

[3] "Cardiopulmonary Resuscitation (CPR) Statistics" (http://www.americanheart.org/presenter.jhtml?identifier=4483). American Red Cross. . Retrieved 2008-10-27.

[4] American Red Cross. *CPR/AED for the Professional Rescuer* (participant's manual). Yardley, PA: StayWell, 2006. (page 63).

[5] de Vries, Lloyd (2006-03-22). "Breathing Easier" (http://www.cbsnews.com/stories/2006/03/22/opinion/garver/main1429483.shtml). CBS News. . Retrieved 2009-04-22. "We got a short lesson in using an AED, which is an Automated External Defibrillator. We had the thrill of yelling, "Clear!" Unfortunately this also brought on a little anxiety when Sean mentioned if the patient were a woman with a metal underwire in her bra or with metal piercings on her torso, we'd have to remove them."

[6] Caffrey SL, Willoughby PJ, Pepe PE, Becker LB (October 2002). "Public use of automated external defibrillators". *N. Engl. J. Med.* **347** (16): 1242–7. doi:10.1056/NEJMoa020932. PMID 12393821.

[7] http://beavermedic.wordpress.com/2010/02/10/look-for-me-in-airportshockey-arenas/

[8] "ILCOR presents a universal AED sign" (http://www.erc.edu/index.php/newsItem/en/nid=204/). European Resuscitation Council. .

[9] "Heartstart Home Defibrillator" (http://www.heartstarthome.com/content/why_defibrillators/why_defibs2_detail.asp). Philips Electronics. . Retrieved 2007-06-15.

[10] Barnaby, Barnaby J (2005-05-03). "Do It Yourself: The Home Heart Defibrillator" (http://www.nytimes.com/2005/05/03/business/03jolt.html?ei=5088&en=84d7afacd0fd7943&ex=1272772800&partner=rssnyt&emc=rss&pagewanted=all&position=). New York Times. . Retrieved 2007-06-15.

[11] *CPR/AED for the Professional Rescuer*, *supra*, page 65 ("[a] safety surgical razor should be included in the AED kit.") The other items not directly mentioned in this text but are used in AED preparation, such as the gloves (used throughout patron assessment) and the towel, as the chest should be dried prior to AED pad attachment (id, at page 64).

[12] "AED Plus Biphasic Waveform" (http://www.zoll.com/product_resource.aspx?id=728). ZOLL Medical Corporation. . Retrieved 2008-10-27.

[13] Introduction to the International Guidelines 2000 for CPR and ECC (http://circ.ahajournals.org/cgi/content/full/102/suppl_1/I-1?ijkey=0ea84b1fa73ef72b72aef923e0f1adc6d4fd6ba5&keytype2=tf_ipsecsha)

[14] Laws on Cardiac Arrest and Defibrillators, 2008 update. (http://www.ncsl.org/programs/health/aed.htm) National Conference of State Legislatures. Retrieved on 2008-03-23.

[15] State Laws on Heart Attacks, Cardiac Arrest & Defibrillators (http://www.ncsl.org/programs/health/aed.htm)

[16] Laws on Cardiac Arrest and Defibrillators (http://www.ncsl.org/default.aspx?tabid=14506)

[17] Health System Improvement Act, 2007 (http://www.e-laws.gov.on.ca/DBLaws/Source/Statutes/English/2007/S07010_e.htm) Retrieved on 26 June 2007

[18] http://www.americanheart.org/presenter.jhtml?identifier=1200000

[19] http://www.redcross.org/services/hss/courses/aed.html

[20] http://www.fda.gov/hearthealth/treatments/medicaldevices/aed.html

[21] http://www.resus.org.uk

Article Sources and Contributors

Automated external defibrillator *Source*: http://en.wikipedia.org/w/index.php?oldid=358597566 *Contributors*: 3MP, 661kts, AEMoreira042281, Aburnett001, Aededitor, Ahruman, Alai, Alan012, Alexius08, AllureOfTheEarth, Andrewpmk, Anon lynx, BRUTE, Bdesham, Beao, Beetstra, Brat32, Brendandh, Byronbarny, CPRLongIsland, Captain Courageous, CarTitans, Cburnett, Cdang, Cfparker, Chaimw21, Closedmouth, Cmichael, Coderedkyle, Compsign, Coralmizu, Cuvtixo, CyberDragon777, Darylcheng, Dbchip, Diderot, Discospinster, Editor at Large, Equendil, Erich gasboy, Gabbe, GeeCee, Gnusmas, GraemeMcRae, Graham87, Gurch, Hashar, Heartguy, Hooperbloob, Hqb, Imroy, Islander, J.delanoy, Jclemens, Jpearson304, Justinfr, KPH2293, Kerttie, Ketiltrout, Khalnath, Killing sparrows, Kjlewis, KnightRider, Kosebamse, Krisjag, Ksheka, Kubigula, Lifeguardmedical, LinguistAtLarge, Lschneid, Lungguy, Lwg9q, M7, MastCell, Mboverload, Medical-Provider, Mherr, Michael Devore, Michael Shields, NawlinWiki, Oden, Owain.davies, PFHLai, Pakman044, Prashanthns, Qoose, RadioActive, Rama, Rambler24, Razalhague, RevRagnarok, RichardNeill, RickK, RioFerdinand11, Rjwilmsi, Robertsteadman, Roysejam, Saaga, SafetyNet, Sam noyoun, Scottalter, Sdlizsmith, Searchme, Shortmang, Sounddude, Stuston, Sultan Edijingo, The Thing That Should Not Be, Tide rolls, TimidGuy, Trusilver, Tsgttucker, Tupolev154, Underpants, Usanetsol, Veinor, VengeancePrime, VigilancePrime, 190 anonymous edits

Image Sources, Licenses and Contributors

Image:AED Open.jpg *Source*: http://en.wikipedia.org/w/index.php?title=File:AED_Open.jpg *License*: Public Domain *Contributors*: User:Owain.davies

Image:CPR training-03.jpg *Source*: http://en.wikipedia.org/w/index.php?title=File:CPR_training-03.jpg *License*: Creative Commons Attribution-Sharealike 2.0 *Contributors*: User:Rama

Image:AED Oimachi 06z1399sv.jpg *Source*: http://en.wikipedia.org/w/index.php?title=File:AED_Oimachi_06z1399sv.jpg *License*: BSD *Contributors*: User:Cory

Image:ILCOR AED sign.svg *Source*: http://en.wikipedia.org/w/index.php?title=File:ILCOR_AED_sign.svg *License*: Public Domain *Contributors*: w:International Liaison Committee on Resuscitation

Image:Defib Checks.jpg *Source*: http://en.wikipedia.org/w/index.php?title=File:Defib_Checks.jpg *License*: Public Domain *Contributors*: User:Owain.davies

Image:Defib electrode placement.JPG *Source*: http://en.wikipedia.org/w/index.php?title=File:Defib_electrode_placement.JPG *License*: GNU Free Documentation License *Contributors*: Andersat, Glenn, Staph, Stevenfruitsmaak, 3 anonymous edits

License

2.8 Defibrillators

2.8.1 Clinical Use and Principles of Operation

A defibrillator is used to reverse fibrillation of the heart, restoring the heart's normally coordinated contractions. The uncoordinated contractions of the heart can take place in the atrial, or upper, chamber of the heart as well as in the heart's ventricular, or lower, chamber. Atrial fibrillation (AF) is relatively common and can be well tolerated by the patient. Ventricular fibrillation (VF) causes the heart to stop pumping blood immediately, and is therefore fatal if not treated within minutes. Death from VF is often called a massive heart attack and is the most common cause of death.

The defibrillator works by delivering a brief, very strong, electrical shock across the chest. The typical pulse is 10 ms and as much as 3000 V. Energies ranging from 300 to 360 J are used during external ventricular defibrillation. While treatment of ventricular fibrillation is the most common use in the developing world, most hospital defibrillators can also treat ventricular tachycardia, where the heart beats too quickly, but in a coordinated fashion. Energies for treatment of ventricular tachycardia are typically below 200 J.

There are several different types of defibrillators. The most common in the developing world is the manual defibrillator. The most common in the developed world is the automated external defibrillators. The implantable defibrillator and the home defibrillator are very rare in the developing world.

The manual defibrillator is commonly found in the developing world. The unit on the left includes an ECG monitor. The device delivers a potentially lethal shock and should be worked on with great care.

The manual defibrillator is a box about 1.5 cubic feet in size, weighing around ten pounds. Cables connect two large metal paddles, which are used to apply the electric shock to the patient. ECG leads can also be connected from the device to the patient. However, most can monitor the ECG through the defibrillation paddles as well. When the ECG connections are used, the ECG can be manipulated in many of the same ways as a bedside monitor.

Defibrillator paddles come in several types: external adult, external pediatric, internal (there are several sizes, all used when the chest is open) and disposable or adhesive electrodes. The external adult and pediatric defibrillators require a conductive gel to be added between the patient and the paddle. The gel is used to assure conduction between the paddles and the chest wall.

The defibrillator works by charging a capacitor, then discharging part of the stored energy in the capacitor through the patient. Older defibrillators discharged through an LCR circuit to the patient. In these devices, the pulse can be as high as 7,500 volts. These discharge circuits have a characteristic waveform to the discharge current called an Edmark waveform. Edmark waveform devices are still very common in the developing world. Because the Edmark waveform can cause severe damage, even death, everyone should stand clear of the patient during the delivery of the discharge of the capacitor. More modern defibrillators discharge the capacitor through a transistor network to deliver a more effective, biphasic, waveform. The biphasic waveform is less likely to cause damage, but the risk still exists.

All defibrillators have a battery back-up system. This way you can bring the defibrillator to the patient, instead of bringing the patient to the defibrillator, which could add minutes to the time until VF is treated. Batteries are often the reason that defibrillators are heavy. Unfortunately, they are also, often, the cause of their failure in the developing world.

2.8.2 Common Problems

Defibrillators are highly reliable devices which require relatively little maintenance if properly stored and used. The most common problem in the developing world is the batteries. Batteries should be replaced every 24 months, or less, to assure proper operation of the defibrillator. However, this is almost never done in the developing world. Refer to the battery chapter for instructions on replacing and testing batteries.

If the batteries cannot be replaced, some defibrillators will not work. However, some will function on mains power alone. If the defibrillator is destined for the OR, the need for batteries is minimal. If the unit is destined for the ER, and won't operate without batteries, it is better to send it back with a very long extension cord, rather than deny ER their only defibrillator. For EMT's a defibrillator without functioning batteries has no value.

Some defibrillators will contain a synchronizer for atrial defibrillation. This is rarely used in the developing world, but can cause problems if the user unwittingly engages the synchronizer. For ventricular fibrillation, the synchronizer plays no role and should be switched off. If this feature is broken, the synchronizer should be bypassed or its sensitivity increased to trigger the discharge.

2.8.3 Suggested Minimal Testing

There are a few maintenance issues that you should take care of before releasing the defibrillator to the floor. The gel will sometimes build up on the paddles and have to be cleaned. Alcohol will soften the gel and make removal easy.

The external paddles should be inspected for pit marks; these could cause high current density and leave burns on the chest. The marks can be removed using emery sand paper. Internal paddles should be inspected to be sure that there are no breaks in the insulation around the conductive part of the paddle. If breaks are present, attempt to repair them with epoxy or a dip plastic. Tape will not withstand OR.

You should test the defibrillator before returning it to the floor. If the defibrillator is not defibrillating, the patient may die. However, the defibrillator should never be discharged by putting the two paddles or electrodes together and pushing the discharge switch. At a minimum this will damage the paddles and potentially the unit.

Ideally, you should discharge the defibrillator through a defibrillator tester. However, these are rare in the developing world. Some defibrillators have an internal test load that you can use. Engineering World Health has recently begun distributing limited-function defibrillator testers free-of-charge. You can contact them to obtain one. However, in most cases, you will have no tester and no internal test load.

If you find yourself without any testing equipment, you can try defibrillating through a large piece of meat. While either chicken (or better turkey), pork or beef will work, you can often purchase a freshly killed pig at very low cost in the developing world. Be sure to place the paddles on opposite sides of the animal, at least six inches between the closest approaches of the paddles. Also, be sure you are wearing gloves and no one else is touching the animal. Gel is required between the paddles and animal, but be sure the gelled areas of the skin are no closer than six inches A freshly killed pig will jump several inches when a defibrillation pulse is properly applied. Large edemic (red) areas will quickly develop where the paddles where applied. The pig is safe to eat after this procedure, after you remove the gel.

In the absence of freshly killed pig, the next best choice is a large piece of dead meat. You need something large enough that the defibrillation paddles are never less than six inches apart at their closest approach. Of course, the dead meat won't jump. However, after ten 360 J shocks, you should begin to see burn marks on the meat, typically outlining the electrode placement.

2. Diagrams and Schematics of Defibrillator

Featured in this Section:

Openstax College. “Cardiac Muscle and Electrical Activity.” From the publication: *Biology*. Rice University: 2013, pgs. 805-818.

Wikipedia. “Defibrillation.” *Wikipedia*, p. 1-12. Retrieved from: https://en.wikipedia.org/wiki/Defibrillation

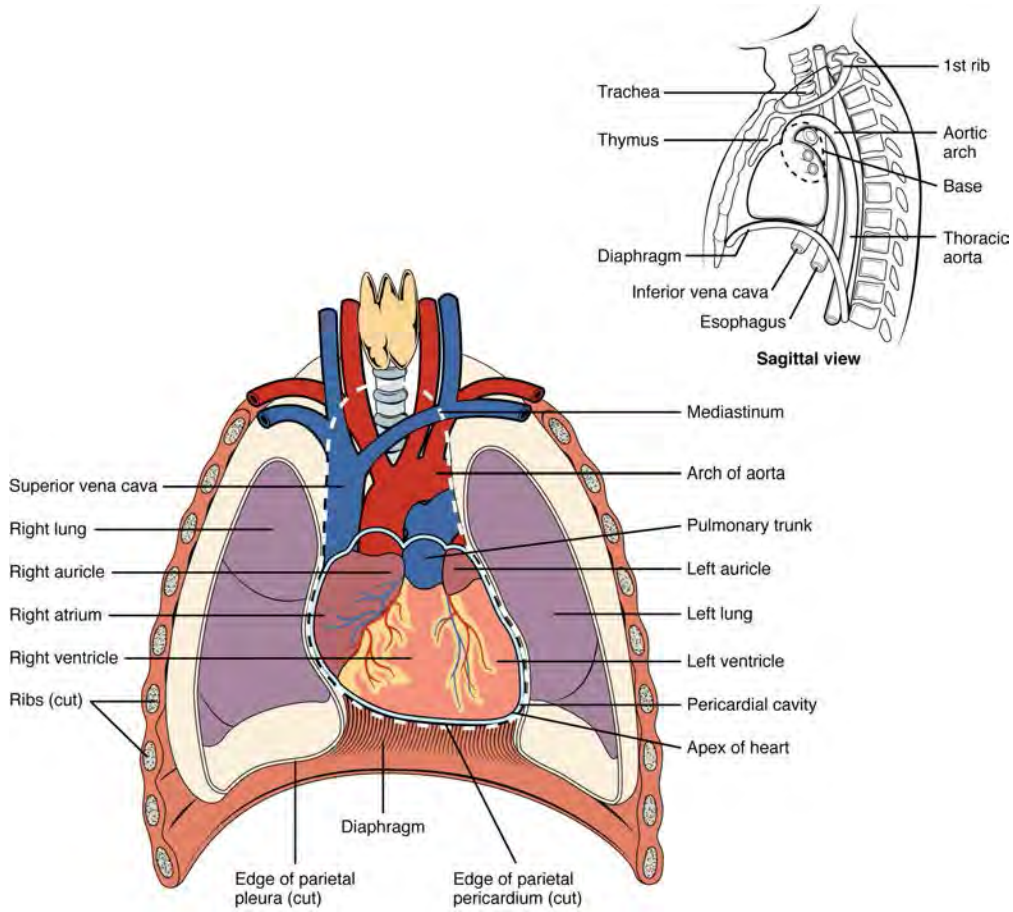
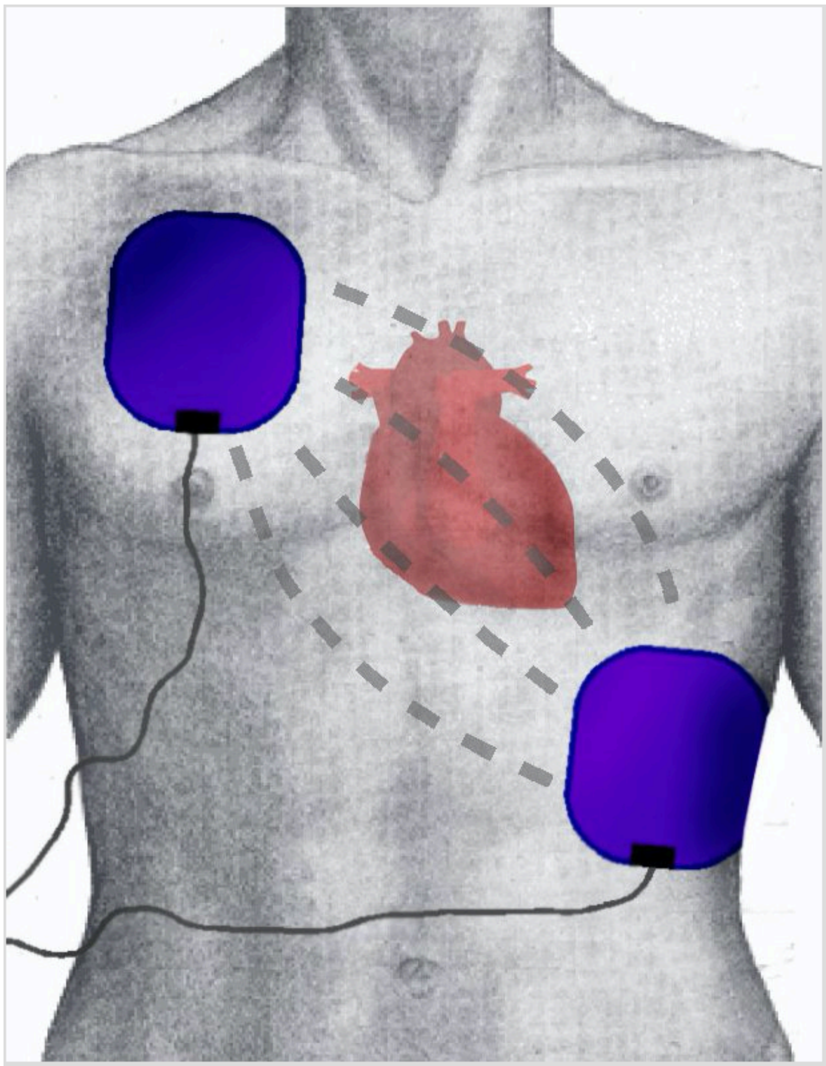


Figure 19.2 Position of the Heart in the Thorax The heart is located within the thoracic cavity, medially between the lungs in the mediastinum. It is about the size of a fist, is broad at the top, and tapers toward the base.

Figure 1: The Human Heart

Openstax College. "Cardiac Muscle and Electrical Activity." From the publication: Biology. Rice University: 2013, pgs. 805-818.

Figure 2: Placement of Defibrillator Paddles



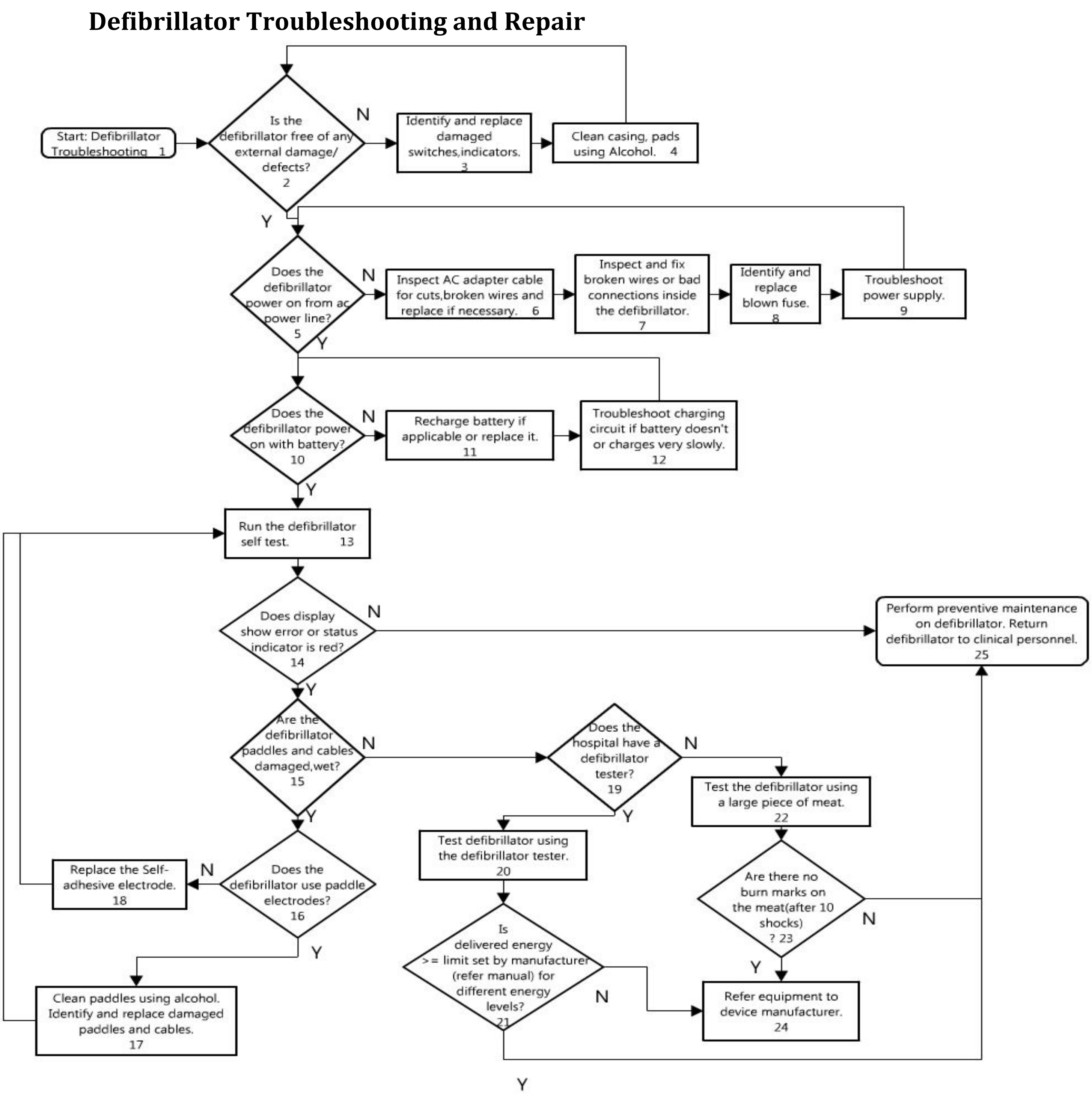
Wikipedia. "Defibrillation." Wikipedia, p. 1-12. Retrieved from: https://en.wikipedia.org/wiki/Defibrillation

3. Preventative Maintenance, Troubleshooting, and Repair of Defibrillators

Featured in this Section:

Cooper, Justin and Alex Dahinten for EWH. “Defibrillator Troubleshooting Flowchart.” From the publication: *Medical Equipment Troubleshooting Flowchart Handbook*. Durham, NC: Engineering World Health, 2013.

Defibrillator Troubleshooting and Repair Flowchart



Cooper, Justin and Alex Dahinten for EWH. "Defibrillator Troubleshooting Flowchart." From the publication: Medical Equipment Troubleshooting Flowchart Handbook. Durham, NC: Engineering World Health, 2013.

Description

	Text Box	Comments
1	Start: Defibrillator Troubleshooting.	Begin diagnostic process for a work order on Defibrillator
2	Is the defibrillator free of any external damage/defects?	Inspect defibrillator for external cracks, broken switch, knobs and indicators.
3	Identify and replace damaged switches, indicators.	See BTA skill set on Switches and Lighting/Indicators to identify and replace damaged switches and indicators.
4	Clean casing, pads using Alcohol.	Examine casing, pads and cables of defibrillator for gel and dirt. Refer BTA skill set on Cleaning to clean the defibrillator. If necessary, address damage to casing with BTA skills on Casing.
5	Does the defibrillator power on from ac power line?	Power the device from ac line and turn it on.
6	Inspect AC adapter cable for cuts, broken wires and replace if necessary.	See BTA skill set on Connections and Connectors for identifying and replacing damaged cables.
7	Inspect and fix broken wires or bad connections inside the defibrillator.	Inspect wires and connections from power supply circuit board to other boards using multimeter. See BTA skill set on Connections for identifying and fixing broken wires and bad connections.
8	Identify and replace blown fuse.	See BTA skill set on Fuse to identify and replace blown fuse.
9	Troubleshoot power supply.	Most defibrillators can power on from battery and ac power mains. See flowchart on Power Supply, and BTA skills on Power Supply.
10	Does the defibrillator power on with battery?	Disconnect defibrillator from ac power line. Turn the device on. • If battery/status indicator is red then battery needs to be charged or replaced (non-rechargeable). • If defibrillator fails to power on then battery is fully depleted or damaged.
11	Recharge battery if applicable or replace it.	See BTA skill set on Batteries to replace and identify damaged batteries.
12	Troubleshoot charging circuit if battery doesn't or charges very slowly.	See BTA skill set on Transformer and Regulators to troubleshoot charging circuit.
13	Run the defibrillator self-test.	Power the device from ac line and turn it on. The device will run an automatic self-test.
14	Does display show error or status indicator is red?	The result of the self-test will be displayed (on the screen) or status indicator will change red/green.
15	Are the defibrillator paddles and cables damaged, wet?	The paddles should be clean and dry. Inspect the pad cables and connectors for cuts and broken wires.
16	Does the defibrillator use paddle electrodes?	Paddle electrodes consist of a metal paddle with an insulated handle.
17	Clean paddles using alcohol. Identify and replace damaged paddles and cables.	Paddle electrodes are reusable and should be cleaned after every use. See BTA skill set on Connections and Connectors for identifying and replacing damaged cables.

Cooper, Justin and Alex Dahinten for EWH. "Defibrillator Troubleshooting Flowchart." From the publication: Medical Equipment Troubleshooting Flowchart Handbook. Durham, NC: Engineering World Health, 2013.

18	Replace the Self-adhesive electrode.	Self-adhesive electrodes should be replaced after every use.
19	Does the hospital have a defibrillator tester?	Defibrillator testing can be done on a commercial tester or a large piece of meat.
20	Test defibrillator using the defibrillator tester.	Connect pads to defibrillator analyzer. Select energy and press charge button. Once charged push discharge button. Record delivered energy from display of defibrillator analyzer. Repeat the procedure for different energy levels.
21	Is delivered energy >= limit set by manufacturer (refer manual) for different energy levels?	Improper functioning of internal circuitry if the defibrillator delivers less or no energy than the limit set by manufacturer.
22	Test the defibrillator using a large piece of meat.	Set energy to maximum and press charge button. Once charged place pads on a large piece of meat. Press discharge button. Repeat the procedure 10 times. The piece of meat should be large enough so that the defibrillator paddles can be placed greater than 6 inches apart.
23	Are there no burn marks on the meat (after 10 shocks)?	Failure of internal circuitry if no burn marks are found on the piece of meat.
24	Refer equipment to device manufacturer.	Refer equipment to device manufacturer for possible repair and replacement of internal circuitry components.
25	Perform preventive maintenance on defibrillator. Return defibrillator to clinical personnel.	Defibrillator is working properly. Perform preventive maintenance before returning the device to clinical personnel.

Preventative Maintenance

Common Reasons for Failure:

- Damaged device
- Damaged pads or cables
- Improper power supply
- Improper functioning of internal circuitry

Cooper, Justin and Alex Dahinten for EWH. "Defibrillator Troubleshooting Flowchart." From the publication: Medical Equipment Troubleshooting Flowchart Handbook. Durham, NC: Engineering World Health, 2013.

4. Resources for More Information about Defibrillators

Featured in this Section:

Australian Defibrillators. “How to Use an AED (Automatic External Defibrillator).” Retrieved from: http://www.aeds.com.au/use-an-aed.html

University of Waterloo. “Building a Defibrillator Tester.” Retrieved from: http://www.eng.uwaterloo.ca/~cube/building%20a%20perf-board%20defib%20tester.pdf

Resources for More Information:

External Resources:

1. **How to Build a Defibrillator Tester: This document demonstrates how to build a homemade defibrillator** tester. University of Waterloo. **"Building a Defibrillator Tester." Retrieved from: http://www.eng.uwaterloo.ca/~cube/building%20a%20perf-board%20defib%20tester.pdf**

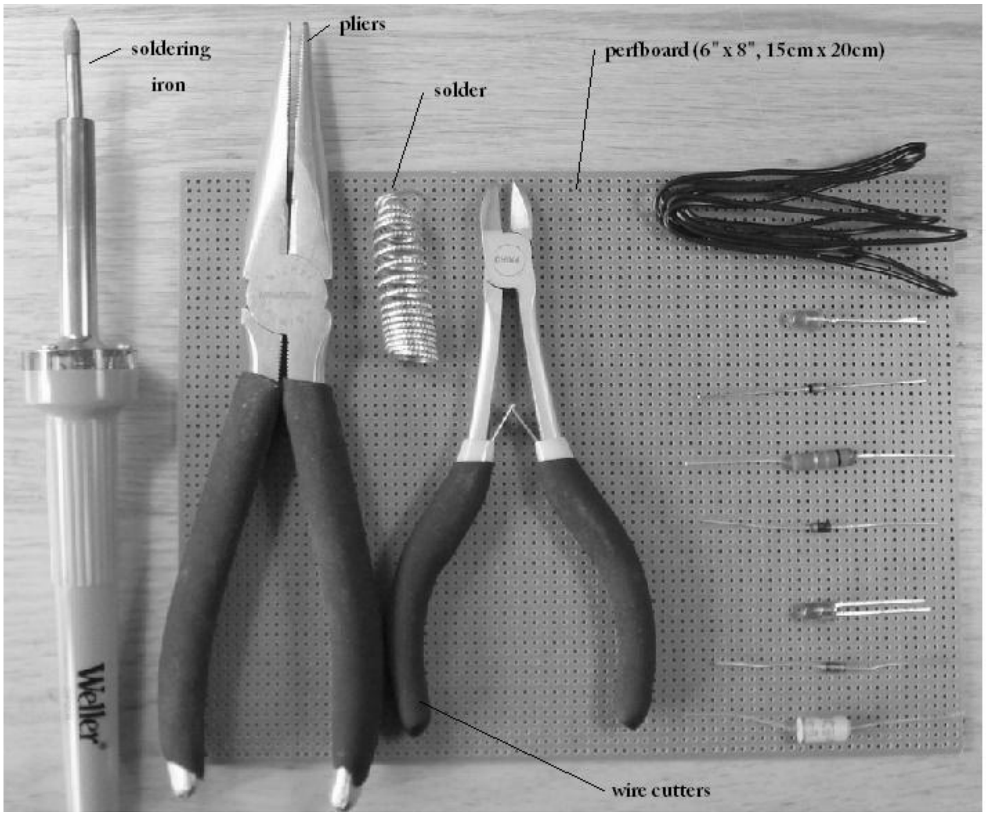
2. **How to Use an AED (Automatic External Defibrillator):** This webpage from Australian Defibrillators explains how to properly use an automatic external defibrillator, including photographs and step by step instructions. **Australian Defibrillators. "How to Use an AED (Automatic External Defibrillator)." Retrieved from: http://www.aeds.com.au/use-an-aed.html**

5 Building a Defibrillator Tester

5.1 Objective:

In this lab you will construct a device that tests the output of a defibrillator to ensure that it can deliver a sufficient shock to restart a heart. This circuit was designed by undergraduate students at Vanderbilt University.

5.2 Parts List:



12V 5mm LED	soldering iron
1W, 3.9V Zener diode	pliers
1.0M ohm, 3W resistor	solder
1A, 50V rectifier	perfboard, 15cm x 20cm
Diffused, round, long LED	wire cutters
2W, 15V Zener diode	super glue
63V, 4.7uF capacitor	wire, roughly 1.2m
permanent marker	multimeter

Figure 1: Parts for constructing the defibrillator tester.

University of Waterloo. “Building a Defibrillator Tester.” Retrieved from: http://www.eng.uwaterloo.ca/~cube/building%20a%20perf-board%20defib%20tester.pdf

5.3 Procedures

5.3.1 Introduction to Defibrillators

A monophasic defibrillator is capable of delivering a 10-350 Joule shock across two paddles or stick-on pads for a duration of about 40 milliseconds. Unlike popular culture's depictions of the machine, defibrillators are not the preferred choice of treatment when a patient is "flat-lining" or has no detectable heartbeat (continued administration of CPR is recommended in these cases). Rather, these devices serve as an electrical reset for the heart and will be most effective when the patient is undergoing ventricular fibrillation (uncoordinated heart muscle contractions). The jolt from the machine clears the random electrical firing causing the lack of coordination, essentially stopping the heart momentarily and allowing structures like the sinoatrial node to regain control of the contractions.

The powerful shock presents several safety issues: when using defibrillators, never allow the two paddles to touch each other; this could harm the operator and severely damage the device. In a real life use of a defibrillator, no one should be in contact with the patient being shocked. A small amount of gel should also be used on the paddles, lowering resistance of the body and helping limit burns where the paddles are placed.

5.3.2 Defibrillator tester design theory

The circuit you will construct is designed to output a visual signal based on the power of the defibrillator that is being tested. If, during the test, the defibrillator is outputting 11 Joules (equivalent to 388V across the grids) in this circuit or less, neither of the two LEDs will light. When a defibrillator's shock contains more than 11J but less than 150J (1410V), the 12V LED will turn on. Unless the parts list has been modified, this 12V LED is the green LED. A shock with more than 150J will activate both LEDs. The power values are relevant in understanding the functionality of the defibrillator being tested. The equivalent voltages, derived based on the circuit's construction, are relevant when the tester *itself* is being tested. Later in this lab, power supplies will be used to ensure the defibrillator testers are lighting up near the appropriate voltages.

5.3.3 Assembling the circuit

The circuit will be laid out on perfboard such that the electronic parts are in a central column. The paddles of the defibrillator will be placed onto bare-wire grids on either side of this column as show in the sketch below.

Figure 2: The general layout for the defibrillator tester.

You will begin by laying out and soldering the electronics area. Before beginning, ensure you keep track of the identity of each part during assembly. This is especially important for the 2W Zener diode and the rectifier as the two components appear very similar.

The circuit should be laid out in a similar manner to Figure 3. Notice that two imaginary columns of holes are visible in the perfboard and that the lead of every component falls into one or both of these columns. Also note the polarities indicated in the text to the right of the figure. The negative terminal of an LED is slightly shorter if the LED has never been clipped; the negative end may also be identified by a slight flat area near the bottom of the plastic case of the LED. Other diodes have their cathodes distinguished by a colored band.

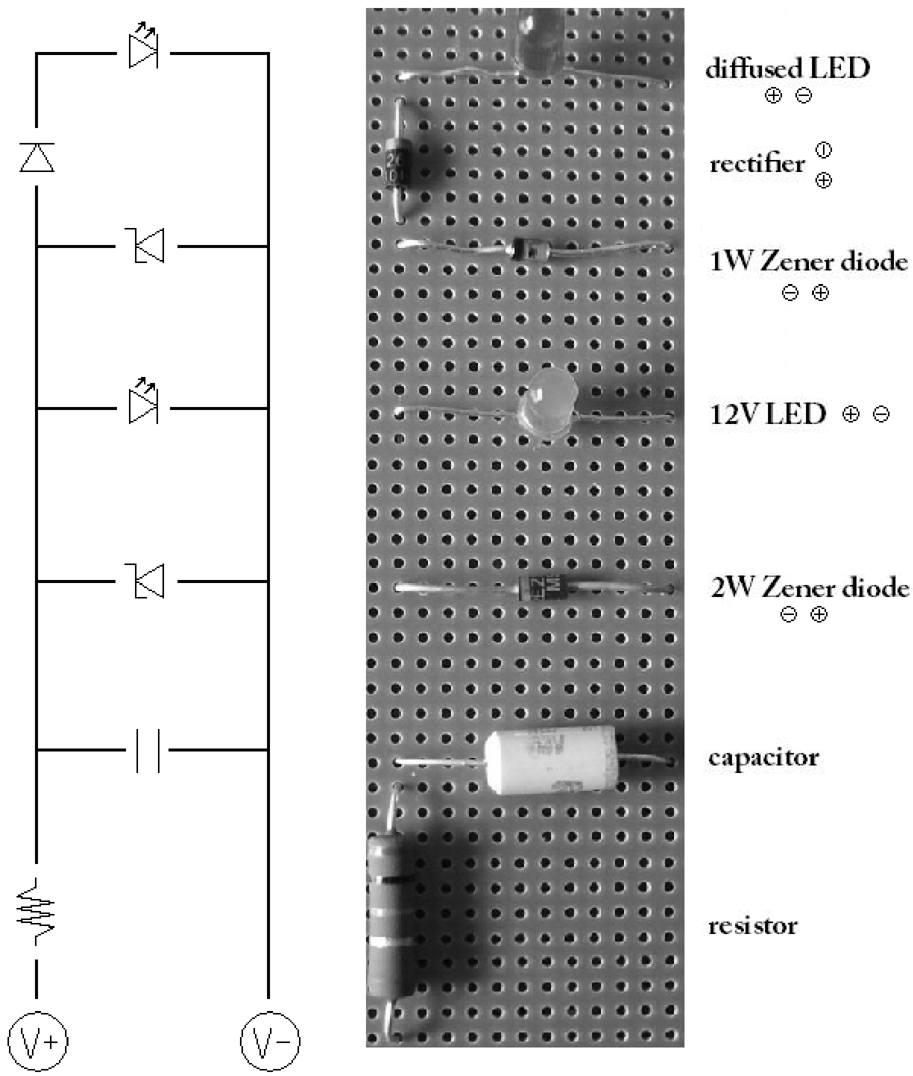


Figure 3: Top layout of the circuit. The + and – symbols indicate the polarity of each piece.

A soldering job like that performed in the soldering lab can be completed on three of the connections in the circuit. In these cases (seen for both leads of the rectifier and one lead of the resistor) connections from one component are being directly soldered to the leads of another part. Be sure to use the hook and hook connection technique.

The other connections require small jumper wires. These can be made from the piece of wire in the parts list or they may be purchased. Seven small jumpers will be required. Figure 5 shows the completed "electronics column" from the top and bottom.

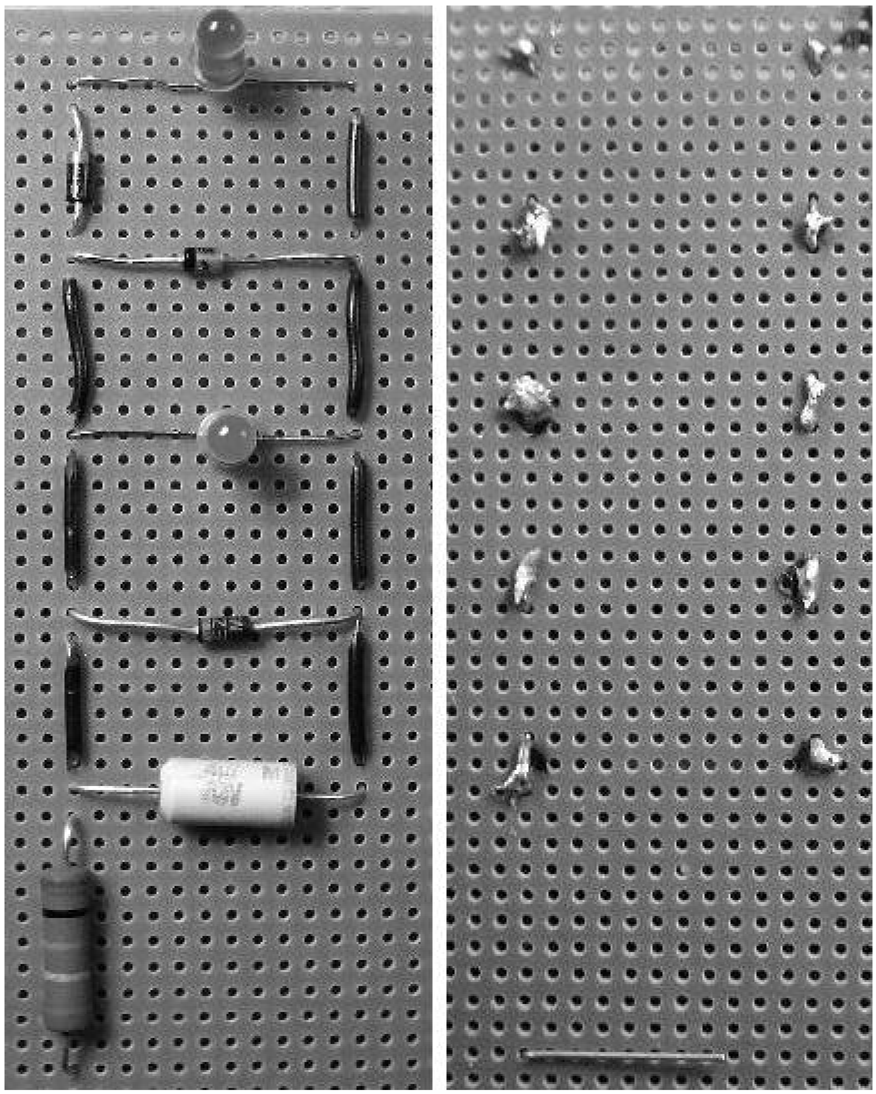


Figure 5: The front and back of the completed "electronics column."

The circuit schematic in Figure 3 shows where power will enter the circuit. Two separate meshes of exposed wires will be made in this step and then electrically connected to the column of electronics. When a defibrillator is being examined, the paddles will be placed on the grids and then the shock will be administered.

You will first need to remove the insulation from approximately 1 meter of wire; it might be easier to do this with a knife rather than traditional wire strippers. Run the edge of the blade down the length of wire until you can barely see the metal beneath the plastic. If you're nimble, you should be able to pull back the plastic cover, separating it from the rest of the wire. Peel the

University of Waterloo. "Building a Defibrillator Tester." Retrieved from: http://www.eng.uwaterloo.ca/~cube/building%20a%20perf-board%20defib%20tester.pdf

covering back to the start of the cut, slice the plastic off, and repeat the process until the entire wire is bare.

The mesh will be approximately 1.5" x 2.5" or 4cm x 6.5cm. To provide a more uniform contact area between the device and tester, the longer wires should be woven in between the shorter, horizontal wires. After the horizontal wires have been put in place, lay down the vertical wire such that it alternates passing above and below the horizontal ones. All intersections should be soldered together so the entire grid is electrically connected. A completed mesh can be seen in Figure 6; remember to make one on the left of the electronics column and another mesh for the right.

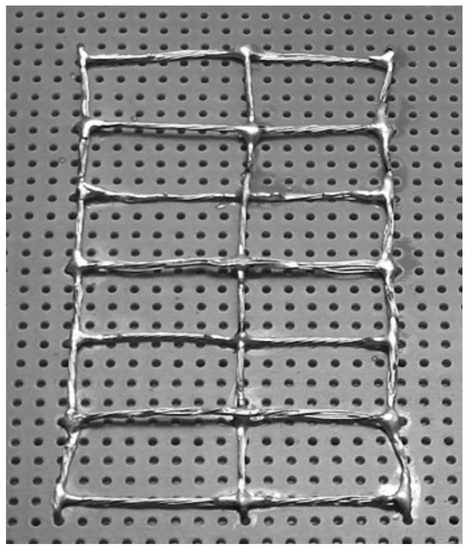


Figure 6: One of two completed meshes, the contact point for the defibrillator's paddles. Each intersection is soldered above the board. The corners are soldered below the board to keep the grid in place. The three vertical wires are woven among the seven horizontal wires to improve the contact area's uniformity.

Once the paddle meshes have each been made on the board, they will need to be connected to the electronics column. This is accomplished via two more small jumpers. So long as the schematic shown in Figure 3 is followed, the physical placement of the jumpers is irrelevant. Figure 7 depicts the completed defibrillator tester.

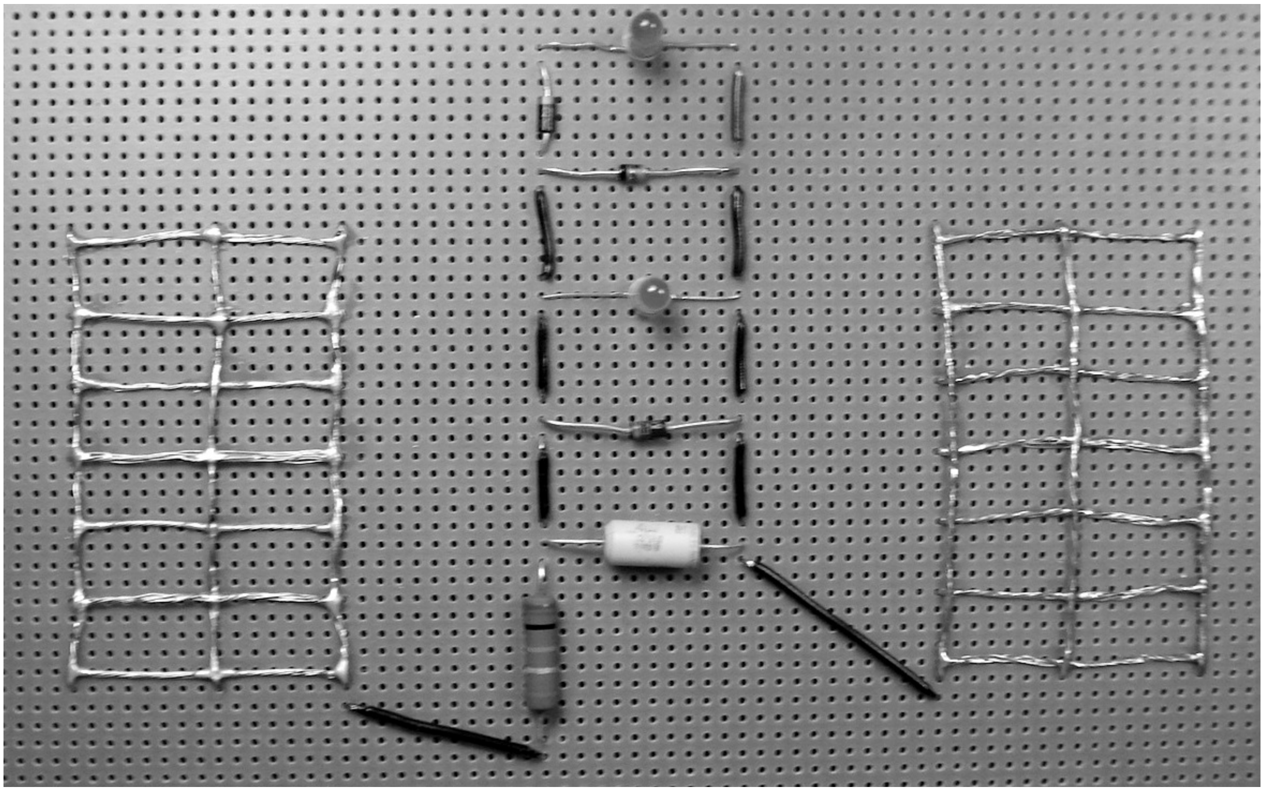


Figure 7: After the paddle-to-electronics jumpers are installed, the board is complete.

5.3.4 Testing the circuit

The device you just completed needs to be tested to ensure the LEDs light up at the correct voltages. If you have a defibrillator, simply check that the device lights up as expected (note that it won't necessarily work with the newer biphasic defibrillators).

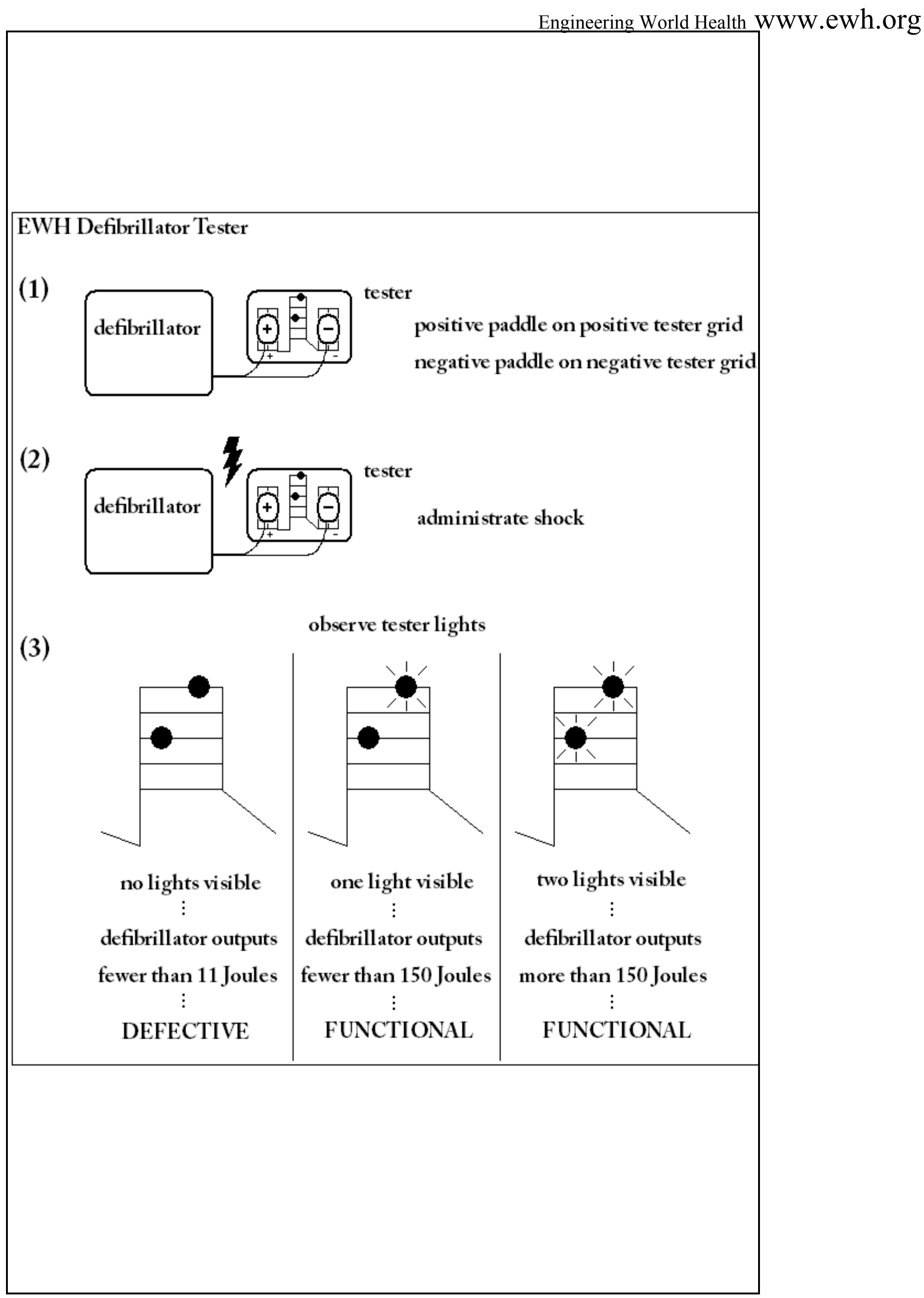
If you don't have a defibrillator, you can still test your device. Two tests will be used, the first of which requires a completed power supply from another lab. If that section has not yet been covered, perform the alternate test first and return to this lab when the power supply is finished.

To verify that your tester works, take the negative lead of the power supply and place it on the grid of wires that directly connects to the capacitor. (This is the negative grid; it is on the right in Figure 7 and should be labeled with a negative symbol using a permanent marker. Also label the right grid with a plus sign.) Make sure the power supply is off. The positive lead should be placed on the capacitor's wire that is nearest the resistor (the left lead in Figure 7). While keeping the leads firmly in place, turn on the supply at 0 volts, then increase the voltage across the capacitor from 1V to around 25V. If the circuit is functioning correctly, the top LED should light up and remain on above a certain voltage level. With the voltage continuing to increase, the second LED should light as well.

The second test makes use of the multimeter. Measure the resistance between the lead of the capacitor nearest the resistor (this lead is on the left in Figure 7) and the positive grid on the tester. The measurement should be close to the impedance of the installed resistor, 1.0M ohms.

5.3.5 Instruction box

The image below should be cut out and super-glued to the back of your functional defibrillator tester.



Defibrillator Bibliography:

Australian Defibrillators. "How to Use an AED (Automatic External Defibrillator)." Retrieved from: http://www.aeds.com.au/use-an-aed.html

Cooper, Justin and Alex Dahinten for EWH. "Defibrillator Troubleshooting Flowchart." From the publication: *Medical Equipment Troubleshooting Flowchart Handbook*. Durham, NC: Engineering World Health, 2013.

Malkin, Robert. *Medical Instrumentation in the Developing World*. Engineering World Health, 2006.

Openstax College. "Cardiac Muscle and Electrical Activity." From the publication: *Biology*. Rice University: 2013, pgs. 805-818.

University of Waterloo. "Building a Defibrillator Tester." Retrieved from: http://www.eng.uwaterloo.ca/~cube/building%20a%20perf-board%20defib%20tester.pdf

WHO. "Defibrillator, External, Automated; Semi-automated." From the publication: *Core Medical Equipment*. Geneva, Switzerland, 2011.

Wikipedia. "Defibrillation." *Wikipedia*, p. 1-12. Retrieved from: https://en.wikipedia.org/wiki/Defibrillation

Wikipedia. "Automated External Defibrillator." *Wikipedia*, p. 1-5. Retrieved from: https://en.wikipedia.org/wiki/Automated_external_defibrillator