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.