Maintaining Defibrillators

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Electrical defibrillation is the single most important therapy for the treatment of patients in cardiac arrest. Most victims of sudden cardiac death initially suffer from ventricular fibrillation, which can lead to a complete absence of electrical and mechanical heart activity within 15 minutes. Cardiopulmonary resuscitation (CPR) may keep blood and oxygen circulating through the body, but only defibrillation can reestablish normal contraction rhythms.

Original defibrillator technology used a monophasic damped sine waveform, which delivered energy through the heart in one direction. Newer technology uses biphasic damped sine waveforms, which send the electrical current through the heart in one direction and then reverse polarity to travel in the opposite direction.

Though both forms have the same overall effect on the heart, biphasic defibrillation can achieve results using less energy than the monophasic waveform. To deliver a 360-J monophasic damped sine wave, 5,200 volts of electricity are needed. Only 1,600 to 1,750 volts are needed to deliver a 150-J biphasic truncated waveform.[1]

In the future, these lower energy requirements could lead to the development of much smaller devices with smaller capacitors and batteries. For now, however, many

facilities are eliminating their monophasic defibrillators to gain the benefits offered by the biphasic technology.

"There are clinical staff who don't understand all the intricacies of the technology, and so don't understand the difference between biphasic and monophasic," says Christopher G. Nowak, CBET, regional director, Mercy clinical engineering services, St John's Regional Health System, Springfield, Mo. "It's incumbent upon us in clinical engineering and biomed that we become the technical experts, and that we educate those who have to use the technology. We keep our finger on the pulse of technology and are able to communicate those benefits to the nontechnical staff."

Those benefits include the fact that the biphasic defibrillator uses less energy, so there is less damage to the myocardial tissue and less neurological damage, according to Andrea L. Borowiec, CE, medical engineering department, Summa Health System, Akron, Ohio.

"Summa started transitioning to biphasic devices about 4 years ago and only has a handful of monophasic devices left," she says. "We are also placing automated external defibrillator (AED) units in our outpatient areas to enhance response time when a resuscitation team is called."

Maintaining Defibrillator Equipment

Whether a defibrillator is monophasic or biphasic, manual or automatic, maintenance needs are similar. Preventive maintenance (PM) is done annually on a staggered schedule and according to the manufacturer's guidelines.

"During PM, the unit's output and integrity are the main parts we check, as well as the function of the whole system," says David Scott, CBET, biomed department, Hospital Shared Services, Denver. "We use a defibrillator tester into which we can discharge the defibrillator in different power settings and record the output. Then we can compare tests from a year ago to those we did today and see if there is any drop-off in

power, which might indicate a problem with the defibrillator—possibly the charge capacitor. Then we will have to troubleshoot the unit."

"Defibrillators do not have a complicated PM or performance verification, but maintaining them is time consuming because the units have so many features, like pacing, pulse oximetry, and a transport monitor that includes electrocardiogram (EKG), noninvasive, and invasive blood pressure," Borowiec says. "So for physiological measurements like blood pressure or EKG, we have test equipment that is the same that we'd use on a bedside monitor. We use a pacing tester to test the pacer function."

In addition to annual testing, unit staff members do a check of the equipment at the start of every shift change. Following a brief checklist, the staff does a test defibrillation, confirms that the equipment is charging correctly, and ensures that all the necessary supplies, like electrodes and disposable patches, are present. Making sure that the cover has no loose components; that all the cables of the device are without fissures, cuts, or broken wires; and that the exterior and the connector are cleaned and disinfected are also important to how well the equipment operates.

"Most people have a procedure that they follow for check- out," Scott says. "They may introduce resistance between paddles with a decade box to simulate patient impedance, but no matter what you are discharging, all defibrillators, monophasic or biphasic, use a 50 ohm noninductive test load."

After a defibrillator is used on a patient, staff in the unit where the device has been used are required to do a similar check before putting the device back in service.

Technology Improves Reliability

Since today's defibrillator technology is fairly reliable, biomeds report few problems with defibrillators.

"We've had a few instances of the unit being dropped during transport," Borowiec says. "We had one come down to our department the other day that was pretty much in pieces because the patient had kicked it off the bed. In this case, the holder for the paddles on top of the unit was cracked in pieces and the handle was cracked off, but the unit itself was operational, and the rest of the case was completely intact. Defibrillators are actually fairly durable."

AED Technoloogy

Many of the new automated external defibrillators (AEDs) are also using biphasic technology. AEDs have been created so that the layperson can easily administer defibrillation to a patient in cardiac arrest by following voice or visual instructions. The

AED device—or a manual defibrillator that has been programmed to AED mode—has the capability to analyze ventricular fibrillation in a patient and deliver shocks when it is appropriate. Such devices also deliver prompts and instructions for cardiopulmonary resuscitation.

St John's Regional Health System, Springfield, Mo, is one of the many facilities that is just beginning to implement AEDs in areas of its facility where no critical care staff are stationed.

"I have just finished an audit of our main campus and have identified quite a few areas where an AED unit should be placed," says Christopher G. Nowak, CBET, regional director, Mercy clinical engineering services, St John's Regional Health System, Springfield, Mo. "Places like the gym and within the tunnels under the campus are ideal. We encourage people to exercise in these tunnels, and yet there are no defibrillators there. Those tunnels can be half a mile long, and it would be difficult to get a code team down there quickly in the event that someone goes into cardiac arrest. In fact, I am now working with administration to develop a plan to implement more AEDs around the campus."

Because it may be several months, or even years, before AEDs are actually used, it is important to have an effective maintenance process in place. During the time between uses, pads may expire and dry out, and batteries may die, so making sure AEDs are ready to be used at any time is paramount. For this reason, most AEDs do a lot of self-checking.

"They have a display that is either an hourglass or a big red X, so all you need to do is look at the defibrillator, and if there's a big red X, then there's obviously a problem," says Andrea L. Borowiec, CE, medical engineering department, Summa Health System, Akron, Ohio.

A defibrillator equipment and maintenance worksheet is useful to record and track changes and will help biomeds stay on top of AEDs scattered throughout a facility. In addition, look for online AED maintenance tracking programs to provide easier documentation.

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Nowak agrees that transportation factors are responsible for the majority of problems he sees. "We have some large defibrillators; Lifepak 12 is most of my fleet, and those are 22 pounds, so they're bound to get dropped once in awhile," he says. "We keep a supply of plastic cases upstairs for such instances."

Batteries are another issue that biomeds find themselves addressing."We've been finding with the Lifepak 500 AEDs that the battery will lose an additional 20% of its useful life when the unit does its daily self-check every morning," says Geoffrey Smith, CBET, biomedical department, Affinity Health System, Oshkosh, Wis. "So, 40% of the battery's useful life is depleted after 1 year, whether it is used or not.

"In our facility, security also walks around the hospital and does checks every morning, and we're finding that they are bringing the AEDs down frequently because their screens are showing low battery power," Smith continues. "Situations like this do make us look at how long we can go between battery checks. Checks are once a year at this point, but we might be moving it up a bit."

"A lot of the new devices use smart batteries with a computer chip that communicates with the defibrillator," Borowiec says. "So if the unit needs to be calibrated, it will show an error message on the defibrillator, and the unit staff will report a malfunction. We have a unit that will cycle the batteries and recondition them. We keep one spare battery at all times, so there is no downtime for the user."

Other problems that biomeds encounter involve wear and tear on the equipment, like breaks in the wiring on the cables that go to the paddles.

"Those breaks occur from use, age, and stretching the wires, and we've found most of those during PM," Scott says. "Still, there are not even a lot of those, and it's very rare that we actually have a cable break on a defibrillator. We have also seen pits on the paddles as well, which occur when the paddles are not seated all the way in the storage wells when staff does a self-test. Pits can lead to a hot spot and burn the patient, so we have to be careful of those."

With advances in the technology come periodic upgrades. Until recently, AED algorithms called for a period of rhythm analysis after each shock to see if another shock was needed. If a shockable rhythm persisted, AEDs gave up to three stacked shocks in succession without CPR (which would interfere with the automated rhythm analysis).

These periods without chest compressions have been shown to be harmful, and the American Heart Association's (AHA) 2005 Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care changed the algorithm so that each shock is followed by 2 minutes of CPR before another rhythm analysis. AEDs still require approximately 10 to 15 seconds of time without CPR for rhythm analysis; for this reason, the AHA now discourages the use of AEDs when a manual defibrillator and trained operator are present.[2]

This change in protocol meant that biomeds needed to upgrade every defibrillator in their facilities, but the task was relatively easy because of the software provided by manufacturers.

"Since all of our units had that function—prompting the user to shock three times—we had to go around and change 100 defibrillators to now prompt the user to shock once and do 2 minutes of CPR," Borowiec says. "Since the software is on a memory card, it was easy to pop that in and do the upgrades on each unit. We no longer need to buy new hardware; in fact, it's easy to upgrade the units now."

No software was available for Medtronic units when the time came to fix this year's daylight saving time, according to Nowak.

"We didn't have a software solution because Medtronic had stopped shipment for a while because of issues with the FDA," he says. "We had to remove the automatic update on each defibrillator and change it manually, but it wasn't difficult."

Maintaining the newer types of defibrillators may be fairly straightforward, but as Smith notes, making sure they are ready for use at all times is an integral part of a biomed's job.

"Battery checks, output checks, pacing checks are all very simple to do, but the one time that defibrillator needs to be used, it has to be ready to go," he says. "When we hear 'Attention in the hospital, Code Blue, ICU,' I want to be confident the defibrillator they may use has been fully checked. We never take shortcuts on any performance check. Not one of our units can ever be overlooked. When those units leave my desk, or when I unhook my test equipment and go on to the next piece of equipment, I want to be absolutely positive that that defibrillator could be used on a family member of mine."

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