

TIME WILL TELL: EARLY DEFIBRILLATION IN THE HOSPITAL

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Part II

Now that Part I has reviewed the findings from Chan's study on delayed defibrillation in the hospital, described what we know about the science of ventricular fibrillation (VF) and defibrillation, and supplied an overview of hospital arrest data from the National Registry of Cardiopulmonary Resuscitation (NRCPR), it is time to see how we can bring this research to bear on practice in the hospital. In this issue of Code Communications I will describe factors that influence the success of defibrillation and then move onto ideas of how we can change care and technology in the hospital to improve time to defibrillation.

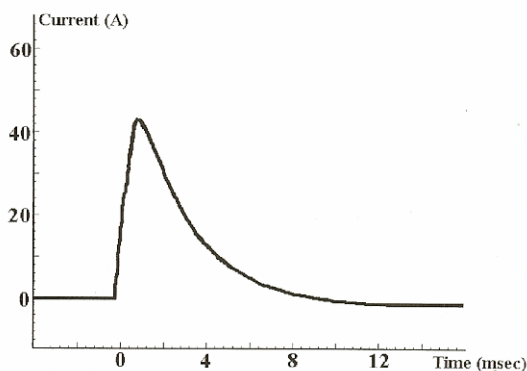
Factors that Influence the Success of Defibrillation

Biphasic Waveform

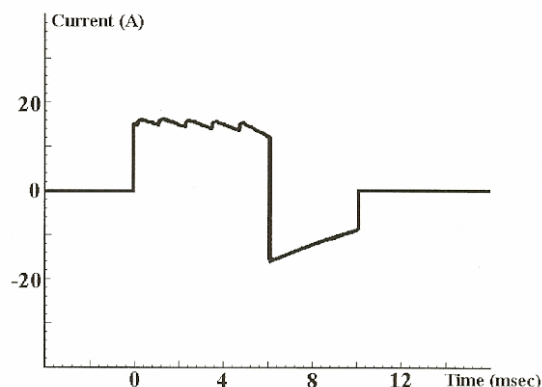
Newer defibrillators incorporating a biphasic waveform compared to a monophasic waveform have been found to have a higher first shock efficacy for VF. Each manufacturer has studies in support of their particular biphasic waveform. In a prospective, randomized, multicenter trial Mittal compared a 200 joule damped sine wave monophasic (MDS) shock to a 120 joule rectilinear biphasic shock (RLB) in ZOLL Medical Corporation defibrillators for 184 patients in VF in the electrophysiology lab setting.²⁰ See Figure 13 for representations of these waveforms.

Figure 13 (Mittal)

**Damped Sine Wave Monophasic
200-J Shock Delivered
Across a 50-Ω Load**



**Rectilinear Biphasic Waveform
120-J Shock Delivered
Across a 50-Ω Load**



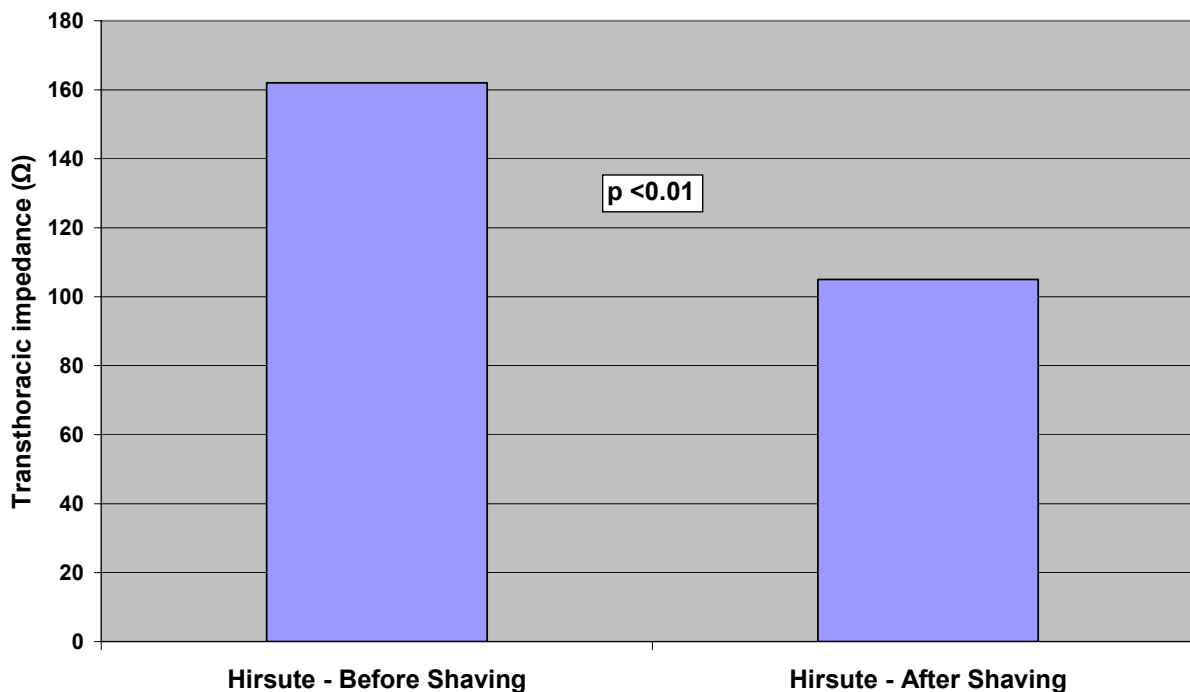
In this study first shock efficacy of the biphasic waveform was significantly greater than that of the monophasic waveform (99% vs. 93%; $p=0.05$) and was achieved with nearly 60% less delivered current (14 ± 1 vs. 33 ± 7 A; $p<0.0001$). Although the efficacy of the biphasic and monophasic waveforms was comparable in patients with an impedance <70 ohms (100% in biphasic vs. 95% in monophasic; $p=NS$), the biphasic waveform was significantly more effective in patients with an impedance >70 ohms (99% in biphasic vs. 86% in monophasic; $p=0.02$).

Morrison et al. showed similar efficacy of ZOLL's RLB waveform delivered with a step-up protocol of 120, 150, 200 joules compared to the MDS waveform with a step-up protocol of 200, 300, and 360 joules.²¹ This prospective, randomized controlled trial was conducted in Toronto with Advanced Cardiac Life Support (ACLS) paramedics responding to out-of-hospital arrests in which at least one shock was delivered. Shock success within the first three ascending energy shocks for RLB was superior to MDS for patients initially presenting in a shockable rhythm (52% vs. 34%; $p=0.01$). First shock conversion was 23% and 12%, for RLB and MDS, respectively ($p=0.07$). No studies have shown a significant advantage of the biphasic waveform related to return of spontaneous circulation (ROSC) or discharge from the hospital. Research continues on the best waveform and the optimal energy level and shock strategy (fixed vs. escalating energy) within defibrillators.

Defibrillation Technique

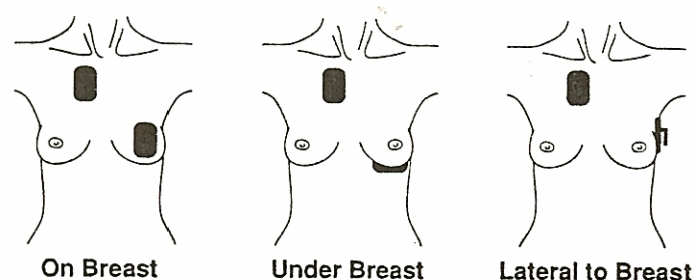
Your technique can enhance the success of defibrillation, so I will review factors that are important to know. Optimal defibrillation technique aims to deliver current across the fibrillating myocardium in the presence of minimal transthoracic impedance (TTI). A study at the University of Iowa showed that shaving the chest of hirsute persons decreased by 35% the TTI measured when disposable electrodes were put in place; see Figure 14.²² It was hypothesized that in hirsute individuals the high TTI resulted from entrapped air (a poor conductor of electricity) when there was not good skin-electrode contact. Clipping of hair is recommended over shaving, which can cause microabrasions and skin burns.

Figure 14 Effect of Shaving on Transthoracic Impedance with Disposable Electrodes (Bissing)



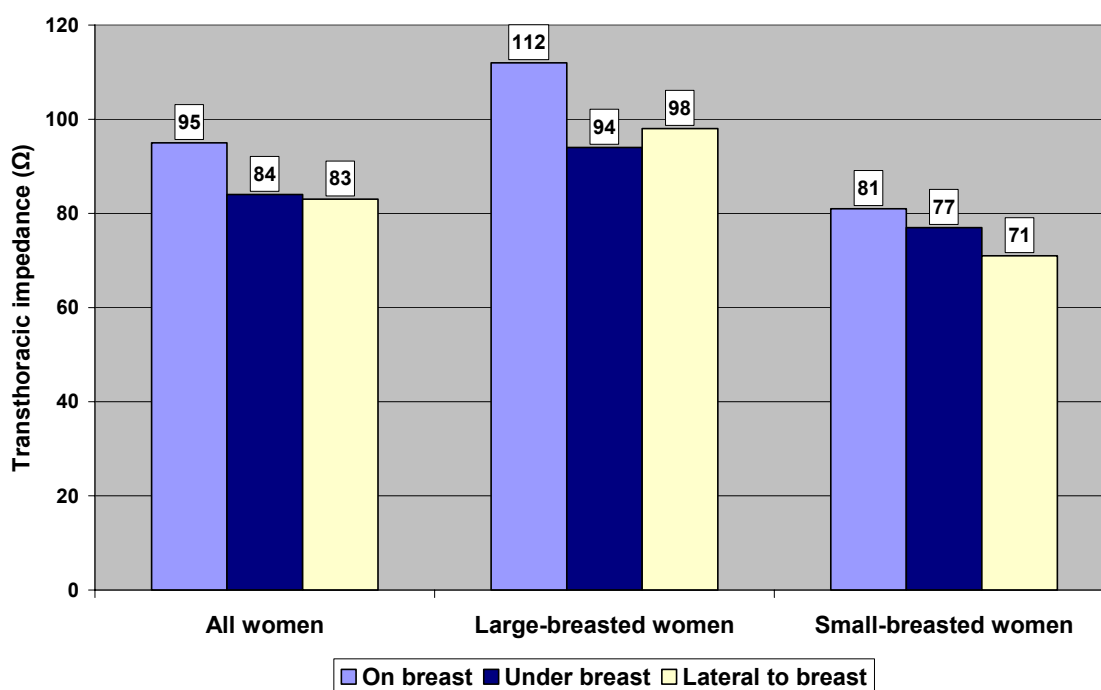
Pagan-Carlo looked at the effect of the electrode position related to the breast, though in his model paddles were used.²³ Three paddle configurations were studied in random order; see Figure 15. The apex paddle electrode was placed in one of three locations: directly on the breast (over the nipple), under the breast (the breast was lifted and the electrode placed underneath), or on the midaxillary line lateral and adjacent to the breast. TTI measurements were made at end expiration while the 23 women and 2 men were holding their breath.

Figure 15 Electrode Placement Related to the Breast for Pagan-Carlo's Study

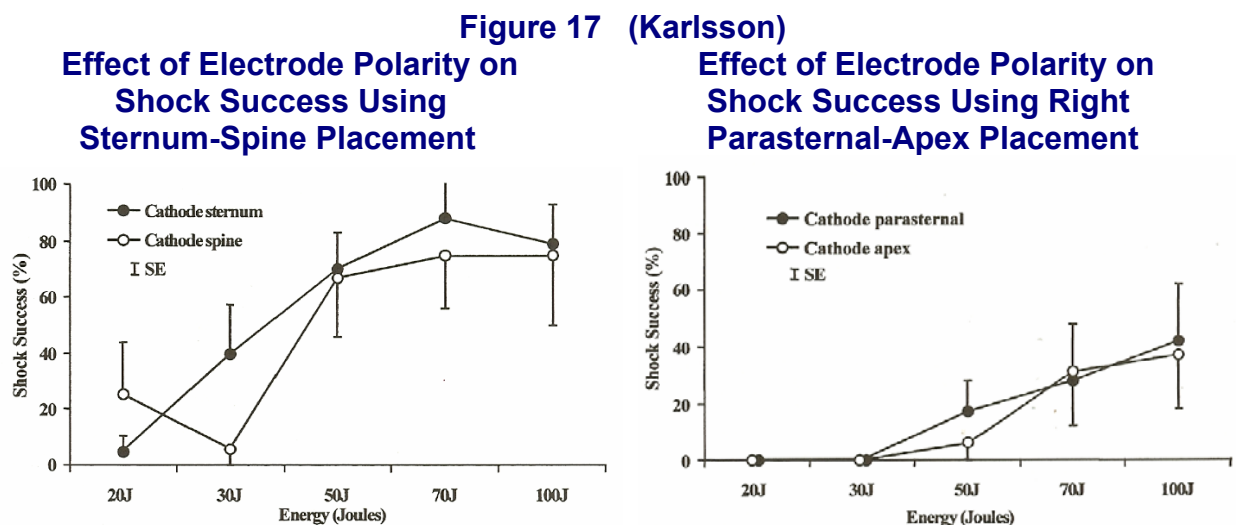


For the whole group and also the group who was large breasted (as measured by bra cup size), TTI was significantly less when the electrode was placed under and/or lateral to the breast compared to on the breast ($p < 0.01$); see Figure 16. With the small breasted women TTI on the breast was significantly higher than lateral to the breast. For two women who had left mastectomies TTI was not significantly different in any of the three positions. Since no actual shocks were given, the authors could not show that avoiding electrode placement on the breast will actually facilitate defibrillation. Nevertheless, previous studies have shown that shock success is lower when TTI is high. It is reasonable to assume that these findings should apply to the use of self-adhesive electrodes.

Figure 16 Transthoracic Impedance Related to Electrode Position (Pagan-Carlo)



Karlsson investigated whether electrode polarity influences the energy requirements for biphasic defibrillation.²⁴ In the porcine model electrode pads were placed in two different orientations on the chest wall: right parasternal-apex and sternal-vertebral column. VF was electrically induced and allowed to persist for 30 seconds. Four truncated exponential biphasic shocks were delivered at each of the following energy levels in random order: 20, 30, 50, 70 and 100 joules. The electrode polarity was varied in random order. See Figure 17.



They found that altering the biphasic shock electrode polarity did not alter transthoracic defibrillation success. It is interesting to note that when the electrodes were placed in the right parasternal-apex position, there was a trend (but not statistical significance) for the shock to have a lower success rate compared to the sternum-spine position, independent of polarity.

There is still a need to determine the optimal position of the self-adhesive electrodes for VF/ventricular tachycardia (VT) so that current passes through a critical mass of myocardium. No studies of cardiac arrest in humans have evaluated the effect of pad/paddle position on defibrillation success or survival rates, according to the 2005 International Liaison Committee on Resuscitation.²⁵ Most studies have evaluated cardioversion or secondary end points such as TTI. In the 2005 American Heart Association (AHA) Guidelines it is recommended:²⁶

“Rescuers should place AED electrode pads on the victim’s bare chest in the conventional sternal-apical (anterolateral) position. The right (sternal) chest pad is placed on the victim’s right superior-anterior (infraclavicular) chest and the apical (left) pad is placed on the victim’s inferior-lateral left chest, lateral to the left breast. Other acceptable pad positions are placement on the lateral chest wall on the right and left sides (biaxillary) or the left pad in the standard apical position and the other pad on the right or left upper back.”

The current ACLS Provider Manual is a little more specific:²⁷

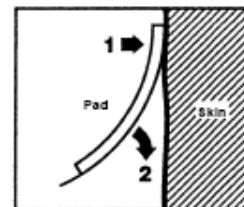
“Place one electrode pad on the upper-right side of the bare chest to the right of the breastbone directly below the collarbone. Place the other pad to the left of the nipple, with the top margin of the pad a few inches below the left armpit.”

The recommended position for the lateral electrode is made more clear in The European Resuscitation Council Guidelines for Resuscitation 2005:²⁸ “The apical paddle [similar for pads] is placed in the mid-axillary line, approximately level with the V6 ECG electrode or female breast.” They state that it is important that this electrode be placed sufficiently laterally. Remember, evidence is still lacking that position of the defibrillation electrodes affects outcome of the patient in VF.

There is one study that compared self-adhesive, dual-function monitor/defibrillation electrode pads to standard chest monitoring leads and hand-held electrode paddles in the management of prehospital VF in a single urban paramedic service.²⁹ Shocks were delivered more quickly following paramedic arrival with self-adhesive pads than with hand-held paddles (1.6 vs. 2.5 minutes; $p < 0.001$). VF was terminated more frequently when shocks were delivered using the self-adhesive pads than when shocks were delivered using hand-held paddles (95% vs. 71%; $p < 0.005$). Patient survival to hospital admission improved when self-adhesive pads were used compared to paddles: 52% vs. 30% ($p < 0.025$). A study by Deakin showed that self-adhesive pads have a similar TTI to paddles.³⁰

Staff should be instructed not to take time to place separate ECG electrodes when defibrillating via self-adhesive pads or paddles unless asystole is suspected. Taking time to apply ECG electrodes prior to defibrillation delays the shock by approximately 30 seconds.³¹

Make sure to roll the self-adhesive electrode smoothly from the applied edge to the other, being careful not to trap any air pockets between the gel and skin, which could increase TTI.



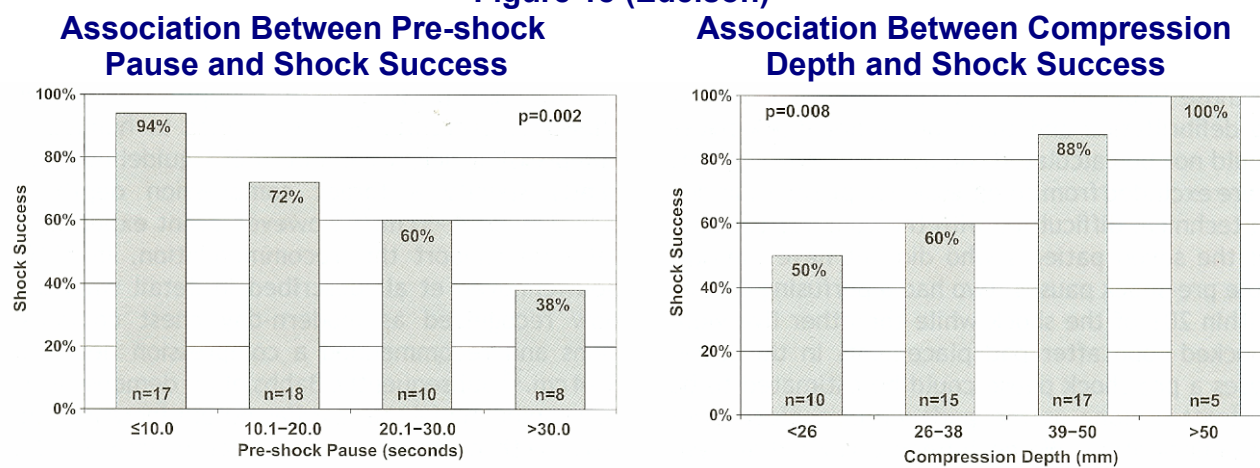
When providing defibrillation to patients with permanent pacemakers or implanted cardioverter defibrillators (ICDs), do not place the electrodes over or close to the device generator. Generally it is taught to position the electrode about one inch away from an implanted device. The device may block some of the current to the myocardium during the shock.³² Do not place the pad over a transdermal patch because the patch may block delivery of energy to the heart and may cause small burns to the skin. Remove the patch and wipe off any medication before attaching the pad.²⁶ If the skin is wet, dry it off before applying self-adhesive electrodes.

Pauses and Compression Depth Prior to Defibrillation

Edelson's important research investigated the effects of compression depth and pre-shock pauses on defibrillation success.³³ A prospective, multi-center, observational study of adult in-hospital and out-of-hospital cardiac resuscitations was conducted between March, 2002 and December, 2005. An investigational monitor/defibrillator equipped to measure compression characteristics during CPR was used. Data were analyzed from 60 consecutive resuscitations in which a first

shock was administered for VF. Successful shocks were associated with a shorter median pre-shock pause duration (11.9 vs. 22.7 seconds; $p=0.002$) and higher mean chest compression depth (39 ± 11 mm vs. 29 ± 10 mm; $p=0.004$) in the 30 seconds of CPR preceding the pre-shock pause. A statistically significant dose-response effect was seen for each factor on first shock success; see Figure 18. Chest compression rate and ventilation rate did not affect shock success. While there was no statistically significant effect of either pre-shock pause or compression depth on ROSC or survival to hospital discharge, patients with first-shock success were more likely to achieve ROSC at some point during the resuscitation (55% vs. 25%; $p=0.04$) and trended toward a higher survival to hospital discharge rate (9% vs. 0%; $p=0.21$).

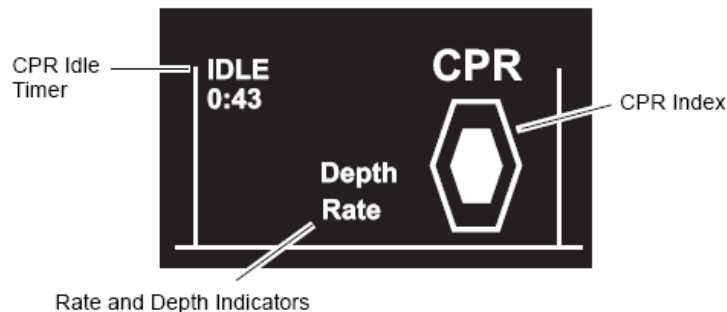
Figure 18 (Edelson)



Several defibrillator manufacturers have released smart products to provide feedback during resuscitations on the quality of compressions and notify providers of significant pauses. ZOLL Medical Corporation now features Real CPR Help[®] using a sternal sensor in their *CPR-D-padz*[®] Electrode, which provides feedback on both rate and depth of compressions. If compressions are less than 1½”, a screen and voice prompt of “Push harder” occurs followed by positive feedback with “Good compressions”. These pads can be used with their AED Plus[®], AED Pro[®], and M Series[®] defibrillators.

In ZOLL’s new R Series[™] defibrillator a CPR Index[™] on the screen provides an overall visual indicator of how the rescuer’s combined rate and depth of chest compressions match the AHA recommendations for adult CPR; see Figure 19. Before chest compressions begin (and after each shock), the CPR Index is displayed as a hollow outline. This index starts to fill from the center out as compressions begin, and becomes fully filled when consistent chest compression depth exceeding 1.75” and rate exceeding 90 compressions/minute are simultaneously achieved. Should the rate or depth begin to fall below the AHA recommended levels, the Index will only partially fill to indicate the need for more vigorous efforts. It takes about 20-25 good quality compressions to become completely full, but empties rapidly when compressions fall below target zones. When complete filling of the CPR Index has not been achieved due to diminished compression rate or depth, the R Series will display the words RATE and/or DEPTH to assist the rescuer in determining which component should be increased. Additionally, once 10 seconds have elapsed without compressions, a CPR idle time is noted on the monitor screen in minutes and seconds indicating how long it has been since the last detected compression.

Figure 19 CPR Index on ZOLL R Series



Philips Medical Systems has the Q-CPR™ feature available with their HeartStart MRx defibrillator. See Figure 20. A sternal sensor transmits information about compression rate and depth to the defibrillator, which is then depicted as a wave graph on the display screen. The wave height depicts compression depth, while the interval between waves indicates rate. The displayed “No Flow” time calls attention to the number of seconds when compressions are not being administered. If either depth or rate drifts outside its target range, the MRx displays on-screen signals and provides audible feedback for correction.

Edelson went on to show that using this real-time audiovisual feedback system alone did not improve ROSC or survival to hospital discharge until the feedback was used during debriefing/teaching sessions with residents and students rotating through the resuscitation team role.³⁴ She collected CPR quality and outcome data from 123 patients resuscitated during an intervention period between March, 2006 and February, 2007 when these staff underwent weekly 30-45 minute discussions using actual performance data obtained from Q-CPR and highlighted deficiencies in CPR quality and defibrillation (RAPID). These data were compared to 101 patients in the baseline cohort, where feedback was only provided during the actual resuscitation using the method described above. See the table below for the results showing improved CPR quality and increased rate of ROSC. No-flow fraction is the time without chest compressions divided by CPR time.

Figure 20 Q-CPR Display on Philips HeartStart MRx



	Baseline	RAPID	P value
Compression depth (mm)	44	50	0.0001
Compression rate (per minute)	100	105	0.003
No-flow fraction	0.20	0.13	<0.0001
Pre-shock pause (seconds)	16.0	7.5	<0.0001
ROSC	45/101 (44.6%)	73/123 (59.4%)	0.03

Summary

From this section we can derive practice measures that can influence the success of defibrillation:

- Utilize defibrillators with a biphasic waveform.
- Shave (or better yet clip) heavy hair on the chest prior to application of self-adhesive defibrillation electrodes.
- In the patient with breasts, place the apex electrode under the breast or lateral (not over the breast).
- Consider placing the electrodes anterior/posterior rather than sternum/apex.
- When placing electrodes in the anterolateral position, place the lateral electrode at the left mid axillary line level with the breast.
- Use self adhesive electrodes rather than paddles.
- Make sure that the self adhesive electrodes are firmly adhered to the chest wall.
- Place the electrodes at least one inch away from implanted pacemakers and ICDs.
- Do not take time to apply separate ECG electrodes unless asystole is suspected.
- Assign a designated team member to monitor compression technique and pauses during both training and actual resuscitations and to give feedback to team members.
- Use defibrillators/devices that give real time feedback on the depth of compressions and pauses.
- Use defibrillators that give printed feedback on compression technique and hold debriefing/teaching sessions with the CPR team afterwards to improve quality of care.

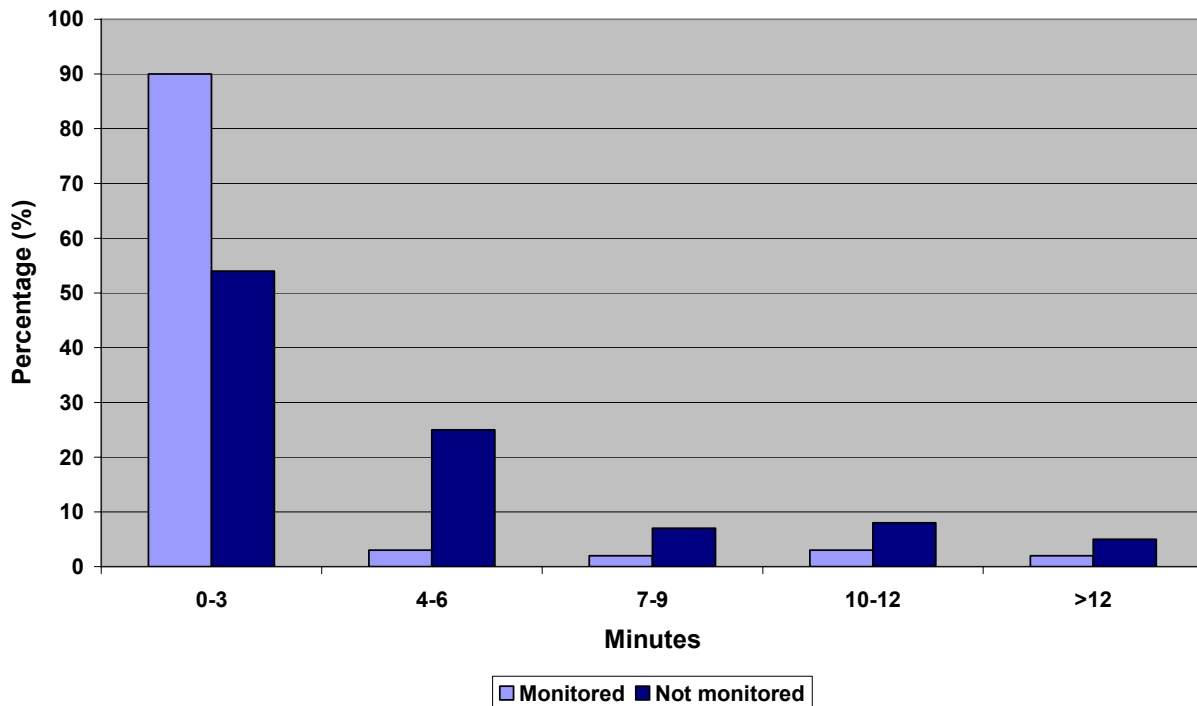
How to Improve Time to Defibrillation in the Hospital

Improved time to defibrillation in the hospital can be achieved by reducing the time to recognition of arrest, decreasing the time to initiate use of the defibrillator, and altering the design of defibrillators so that the shock can be delivered more quickly. Changes in the process of care and technology will be described below to achieve these aims.

Increased Monitoring of Patients in the Hospital

There is a small body of literature that looks at survival of in-hospital patients in monitored vs non monitored units, and how this relates to time to defibrillation. Herlitz studied all patients who suffered an in-hospital cardiac arrest for whom the rescue team was called from 1995 until 2002 in Sahlgrenska Hospital, Goteborg, Sweden.³⁵ For the total study period survival to discharge was an amazing 58% for patients found in VF, 24% for asystole, and 9% for pulseless electrical activity (PEA). On the monitored wards, 59% of the patients were found in VF/VT vs 45% on the non-monitored wards ($p = <0.0001$). The most likely explanation of this finding is that the ECG recording took place much earlier in the course among patients suffering a cardiac arrest on wards with monitoring facilities. On the monitored wards, 90% of patients were defibrillated ≤ 3 minutes after collapse vs. 54% on non-monitored wards ($p < 0.0001$); see Figure 21. The overall survival to discharge for those in VF was 60% in monitored wards vs 57% in non-monitored wards (NS).

Figure 21 Percentage of Patients Defibrillated within Various Intervals after Collapse (Herlitz)



Going back to the study by Chan described at the beginning of Part I,¹ defibrillation was delayed more often when the patient was placed in an unmonitored unit and the arrest occurred after-hours, when presumably less staff are available. Saxon suggests:³

“One can imagine placing simple telemetry electrodes on all high-risk hospitalized patients and wirelessly transmitting continuous ECG data to a computer and alarm station. This station could be centralized within a hospital or to a particular ward. The centralized computer would continuously analyze these data with the use of automated algorithms. If VT or VF was detected, an alarm would be activated outside the patient’s room or at the nursing station. Nurses could also be alerted directly with the use of portable communication devices. The automated detection system offers advantages in that it is insensitive to staffing issues and, if centralized, can track patients anywhere in the hospital. The system also allows for quicker notification of key personnel. Since delays in defibrillation have been successfully overcome with AEDs, these devices could be placed in every patient’s room to enable the first responder to deliver timely defibrillation.”

Fully Automatic External Cardioverter Defibrillator (AECD)

Figure 23
Cardiac Science PowerHeart CRM



Cardiac Science, Inc. has recently introduced the PowerHeart[®] CRM[™], “the industry’s first and only transportable automatic therapeutic vital signs defibrillator-monitor. It combines biphasic defibrillation technology, non-invasive external pacing, and ECG monitoring technology in a portable, compact device, which immediately and automatically monitors, detects, and treats patients who suffer life-threatening tachyarrhythmias.”³⁷ See Figure 23. This battery-operated device, mounted at the hospital bedside, is attached by defibrillation electrodes on the chest wall and can automatically deliver countershock therapy to VF/VT patients with no human intervention. Hospitals report using the PowerHeart CRM most often on telemetry units and in the emergency department. Detection criteria and therapy protocols are easily programmed and customized for individual patients by hospital staff. A European multicenter trial demonstrating efficacy and safety of this new device was reported in 2003 by Martinez-Rubio.³⁸ A qualitative study by Hancock of clinicians’ experiences and perceptions with the AECD was published in 2006.³⁹ More information about this product can be obtained at:

<http://www.pacificmedicalsystems.com/powerheartcrm.htm>

Wearable Cardioverter Defibrillator (WCD)

What about ambulatory patients at high risk for sudden cardiac death wearing an external vest that acts as an automatic cardioverter defibrillator? This futuristic idea is already available as the LifeVest[®] Wearable Defibrillator; see Figure 22. The device continuously monitors the patient’s heart with dry, non-adhesive sensing electrodes to detect life-threatening abnormal heart rhythms. If a life-threatening rhythm is detected, the device alerts the patient prior to delivering a shock, and thus allows a conscious patient to disarm the shock. If the patient is unconscious, the device releases a gel over the therapy electrodes and delivers an electrical shock to restore normal rhythm.

Figure 22
ZOLL LifeVest Wearable Defibrillator



Potential patient groups who may benefit from this technology include:

- Post myocardial infarction patients with complications
- Cardiac surgery patients with complications
- Heart transplant waiting list patients
- Advanced heart failure patients
- Patients undergoing drug testing with potentially pro-arrhythmic medications
- Patients who need an ICD, but have a condition that prevents or delays surgery (e.g. infected ICD pocket)
- Patients who simply do not want to undergo surgery or have an implant

The ZOLL [Resuscitation Central](http://www.zoll.com/ResuscitationCentral) web site reports that to date more than 2000 patients have worn the wearable defibrillator and nearly 100 have been successfully rescued from a life threatening episode of VF/VF – with a 99% success rate. Symkiewicz reported at the 2006 AHA Scientific Sessions on 47 cardiac arrest events in 33 patients wearing the LifeVest between January, 2005 and April, 2006: 38 VT, 2 VF, 7 asystole and 1 PEA.³⁶ VT/VF recurred within 24 hours in 3 events. All events were detected and recorded by the WCD with the exception of the PEA reported to have occurred on a telemetered patient. All patients with VT/VF were treated successfully (converted out of VT/VF and either conscious on emergency room arrival or no need for additional care). Two patients were shocked for sustained VT while conscious. 84% were treated within 60 seconds. Median time to shock from arrhythmia onset was 44 seconds. Patients consisted of ICD explants or surgical delays (76%), prior VT/VF (15%), post MI/CABG with low ejection fraction (15%), genetic sudden cardiac arrest risk (9%), non-ischemic cardiomyopathy (3%), or unknown (3%). More information about the LifeVest can be found at: <http://www.zoll.com/product.aspx?id=902>

AEDs and Two-Tiered-Defibrillation Therapy

Implementation of a two-tiered defibrillator program in a hospital will improve the time to perform defibrillation outside of critical care units. A two-tiered response in the hospital includes using automated external defibrillators (AEDs) equipped with ECG monitoring and manual override for medical/surgical units, diagnostic/treatment areas, outpatient units and public arenas. The cardiac arrest team would have available manual defibrillators with pacing, cardioversion and enhanced monitoring capabilities. AEDs are easy to use, effective, and safe for the basic first responder at a resuscitation. The technology is available from a variety of manufacturers at an affordable price. AEDs are available as a small standalone “shock box”, which is less intimidating to the basic responder, or combined with the manual defibrillator used by the cardiac arrest team. With AEDs, first responders feel empowered by the ability to provide definitive therapy for shockable rhythms rather than only the holding therapy of CPR until the arrival of the advance response team. Time will tell whether hospitals will now commit to this approach in order to improve time to defibrillation.

Several factors are important to the success of a two-tiered defibrillation program. First, gain support from administration and the CPR decision makers in the hospital. Second, involve basic and advance responders in the selection of the device. Walk the hospital landscape so that a defibrillator is no more than one minute away. Plan how to integrate the location and responsibilities related to the AED into annual safety training for *all* employees. Training in the specific AED should be integrated into the hospital’s Basic and Advanced Life Support

education programs. Purchase training equipment that is similar to the AED device itself so training scenarios can be realistic. Policies/protocols should be revised to authorize any trained responder to use the AED in any location on hospital property – prior to the arrival of the CPR team. Defibrillator data should be downloaded so that the hospital can compare its time to defibrillation before and after implementation of AEDs. Kaye’s article on “Organizing and implementing a hospital-wide first-responder automated external defibrillation program: strengthening the in-hospital chain of survival” remains a useful reference for those bringing AEDs newly to a hospital.⁴⁰

Single institutions have reported success stories with implementation of an AED program for first responders. The Atlanta Veterans Administration Hospital replaced all their manual monophasic defibrillators with a combination of biphasic manual and automated defibrillators.⁴¹ With the new defibrillators, survival of all patients with resuscitation events improved 2.6-fold, from 4.9% to 12.8%. The improvement in mortality was attributable solely to an effect on patients presenting with VF/VT; their survival improved 14-fold. At Miriam Hospital in Providence, Rhode Island, Mancini and Kaye report that AED used over 2½ years in non-critical care areas doubled the survival-to-discharge rate (6/10 or 60%) when compared with conventional defibrillation by the ACLS CPR team (9/28 or 32%).⁴² At a university hospital in Germany Hanefeld reports that 14 AEDs were installed so they could be easily reached from the wards.⁴³ During their first year of experience an AED was applied and activated by nurses/medical staff before the cardiac arrest team arrived in 27 of 33 cases (81.8%) of witnessed cardiac arrests. The median time from onset of the emergency call to the activation of the AED averaged 2.1 minutes, whereas the median arrival time for the CPR team was 4.7 minutes. In 18 of 27 cases in which the AED was instituted promptly, the primary arrest rhythm was either VT or VF, and the AED delivered a shock. For this subgroup, the rate of ROSC and the rate of discharge to home were 88.9 and 55.6% respectively.

Kenward published in 2002 a review of primary research related to in-hospital use of AEDs and resuscitation outcome.⁴⁴ Sample size in the five studies that met his inclusion criteria were small, methodological issues were highlighted, and incomplete demographic data precluded metaanalysis. Thus we need higher quality prospective research and audit to confirm that AED use in hospitals will make a difference in patient outcomes.

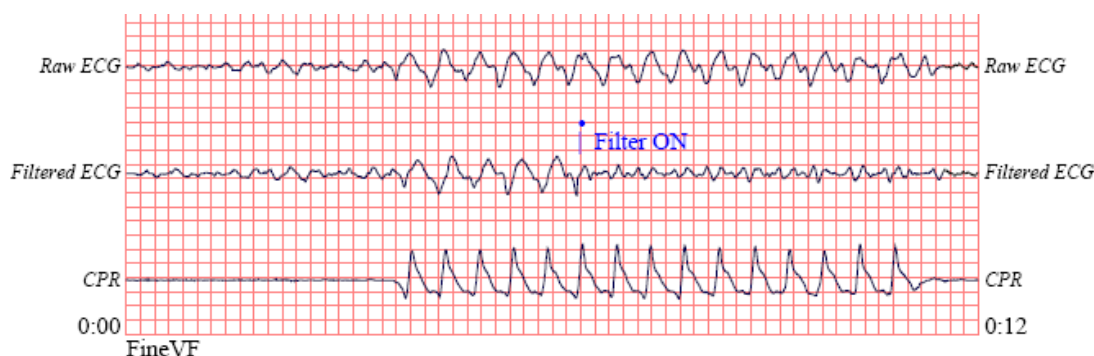
Defibrillator Design

Defibrillators should be designed so that they can be deployed as quickly as possible. When evaluating AEDs for purchase, have neophytes try them out to determine ease of use. Most AEDs are designed with the electrodes already plugged into the device, so they can be quickly attached to the patient. Are the instructions for affixing the electrodes to the patient clear and easy to follow?

The “hands-off” interval between cardiac compressions and subsequent defibrillation shock should be minimized. Defibrillators usually require that the rescuer stop compressions and the patient be still while rhythm analysis occurs so that motion artifact does not interfere with the analysis. Research is being performed to address this restriction, and defibrillator manufacturers have started to address this issue. ZOLL’s new See-Thru CPR™ technology in their R Series defibrillator allows clinicians to see organized electrical activity during compressions by filtering

out artifact; see Figure 23. This lets ACLS rescuers see a patient's underlying rhythm during resuscitation efforts and eliminates the need to stop compressions until just prior to defibrillation for verification analysis. The patient's heart rhythm can be monitored to determine the appropriate time to analyze or stop CPR to check the ECG. How soon will other manufacturers design their defibrillators with filtering of the ECG signal during rhythm analysis so that the hands-off time is drastically reduced? Time will tell!

Figure 23 See-Thru CPR with ZOLL R Series Defibrillator



Can capacitor charge time in defibrillators be minimized and even occur during analysis? Philips Medical Systems has recently released its Quick Shock feature. Their HeartStart AED can deliver a shock typically in less than 10 seconds after the end of the CPR pause. Will other defibrillator manufacturers work on this design change and become more competitive?

The current AHA Guidelines recommend that in the hospital a shock be administered as soon as a defibrillator is available, even if no CPR has been given in advance. But studies have shown that CPR may be the more appropriate first intervention when the time to defibrillation is longer, i.e. the patient is now in the circulatory phase of arrest. Even if CPR was provided early, the technique may not have been performed well and the ECG may show fine VF rather than the more easily converted coarse VF. Both fibrillation mean frequency and amplitude have been shown to be predictive of defibrillation success in animal models with short and prolonged cardiac arrest and in humans during cardiac surgery.⁴⁵ Can smart defibrillators be designed that will analyze the VF waveform and provide accurate cues to guide the rescuer in whether CPR or defibrillation should be provided? Philips recently introduced its Smart CPR feature for the HeartStart FR2 AED. It can be configured either to give a shock first – for systems that always respond in under 4 minutes (e.g. in hospital), CPR first – for systems that always have very long response intervals (e.g. out of hospital), or better yet the AUTO function where the AED decides on the appropriate therapy for each individual patient regardless of response interval or whether good CPR has been done.

Track Your Changes and Success

In order to evaluate whether the changes in practice and technology make a difference, you will need to track their use, process of care time intervals and patient outcomes. Data that will need to be tracked includes:

- Frequency of use of the change in care or technology, e.g. how often first responders apply an AED, how often first responders provide the first shock with an AED
- Location of use of the change in care or technology
- Time from collapse to first defibrillation shock
- Time of return of spontaneous circulation related to initial rhythm
- Patient discharge from the hospital related to initial rhythm
- Patient neurological and functional status at discharge related to initial rhythm
- Problems in use of the change in care or technology

It is essential that an accurate method be determined and used by all resuscitation responders to identify the time of events: time of arrest, time CPR was started, time the first defibrillation shock was delivered, time of first dose of epinephrine, time of return of spontaneous circulation, etc. Providers use a variety of means to note time – wall clock, wristwatch, defibrillator time, bedside monitor time – and these are all different. It would be ideal if all timepieces could be synchronized to one clock, such as atomic time. But atomic time clocks cannot resynchronize to the central transmitter signal within hospital structures. So a next best method would be to come to an agreement to use only one clock during the resuscitation to note times, such as the wall clock in the patient’s room. A new technological advance, ZOLL CodeNet[®], is an electronic resuscitation information management system that synchronizes time across all components: the PDA used for documentation during the code, the defibrillator, and the computer used to complete and print the record. Time synchronization has never been accomplished prior to this innovation in resuscitation care. With CodeNet, time can now be synchronized so that time intervals are believable and quality monitoring can be more meaningful. A hospital cannot evaluate if early defibrillation is actually occurring unless the time interval from collapse to first shock is accurate and tracked. For more information on CodeNet, go to:

<http://www.zoll.com/product.aspx?id=412>

Once accurate resuscitation data is obtained, aggregate reports and graphs can be produced using a hospital’s usual methods and/or the data management programs offered by defibrillator manufacturers. You can benchmark your hospital’s processes of care and patient outcomes with other hospitals by subscribing and submitting data to the National Registry of CPR. For more information on the NRCPR, go to: <http://www.nrcpr.org/>

Conclusion

Now that the reality of delayed defibrillation in the hospital setting has been brought to the forefront by Chan, what will hospitals do with this new information? Can those who are concerned about resuscitation and are in an influential position to make change disseminate the scientific data in a manner that will translate into improved resources – both staff and technology? Time to defibrillation must become a quality indicator, similar to “door-to-balloon” time for hospitals.⁴⁶

Time will tell whether this surprising finding of delayed defibrillation will lead to improvement in our resuscitation practices within the hospital.

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