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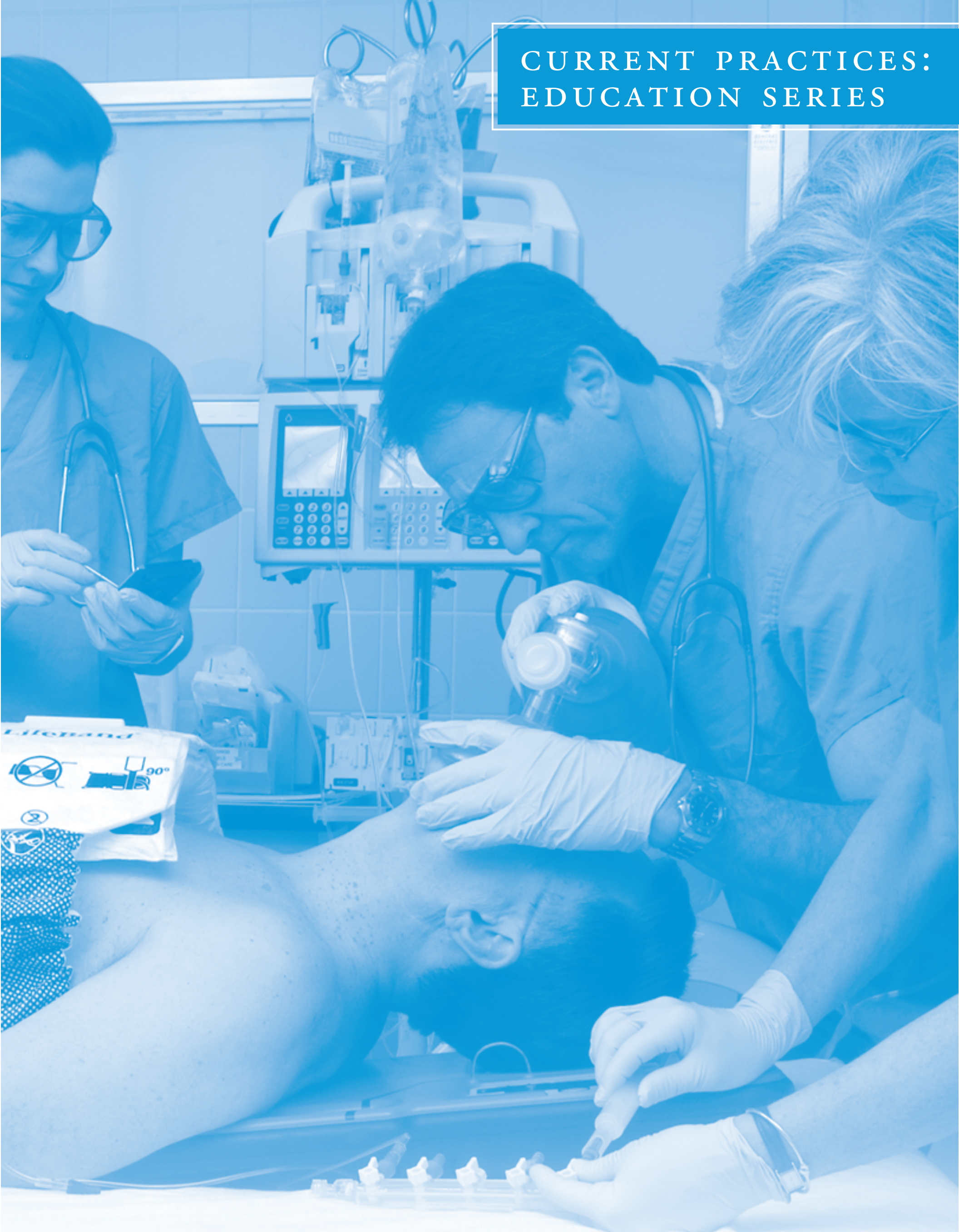
EDUCATION SERIES



IN-HOSPITAL RESUSCITATION AND AUTOPULSE®

Learning Objectives

After completing this course, the learner should be able to:

- Articulate the importance of high-quality CPR
- Discuss the limitations of manual CPR in providing optimal perfusion
- Discuss the benefits and challenges of mechanical cardiac support
- Share real-life experience with program development and implementation utilizing mechanical cardiac support during in-hospital resuscitation

Introduction

In 2005, the American Heart Association (AHA) published guidelines for high-quality, effective CPR. The guidelines recommended a compression/ventilation ratio of 30:2, or 100 compressions per minute; compressions at a depth of 1.5 to 2 inches; to minimize pauses (and to pause only for 10 seconds at a time); and to change providers every 2 minutes.

Abella et al[1] published a prospective observational study of 67 patients in 2005, shortly after the AHA Guidelines were released in 2005, to measure how well clinicians perform CPR. In the study, 40% of patients with in-hospital cardiac arrest had return of spontaneous circulation (ROSC) yet only 10.7% survived to discharge. By reviewing the first 5 minutes of cardiac arrest, it was discovered that compressions were too shallow nearly 40% of the time. In addition, 60% of the time, clinicians were ventilating the patient too frequently, raising intra-thoracic pressure, which, in turn, impedes perfusion. The rate was less than 100 compressions nearly 30% of the time.

The larger issue was the mean no-flow rate of 0.24, indicating that each minute of CPR included a pause of approximately 15 seconds of no-flow time. The Guidelines recommend no more than 10 seconds of pauses in 2 minutes of CPR. The study showed actual pauses were approaching 30 seconds every 2 minutes.

Another study by Olasveengen et al[2] reviewed patients before and after changes to the AHA Guidelines (435 and 481 patients, respectively) to assess the impact of improving CPR. The study found that after adoption of the 2005 Guidelines, the time for pre-shock pauses decreased, hands-off time decreased, and appropriate compression and ventilation rates were reached. However, survival to discharge only increased from 11% to 13%. Clearly, just following the recommendations is not enough. There is more that clinicians need to do to improve patient survivability.

CHALLENGE OF MANUAL CPR

There are multiple studies published that explain why performing good CPR is difficult. One reason is the inconsistency of performance among caregivers during CPR. Unless there is a system where the defibrillator provides feedback on compression rate and depth during CPR, it is unlikely that the AHA Guidelines will be followed consistently[3].

Provider fatigue is also a problem, as published by Sugarman et al[4]. Fatigue leads to decay of compression depth. It has been shown that providers need to be changed every minute to achieve good CPR. Unfortunately, changing providers every minute increases hands-off time and interrupts the flow of resuscitation.

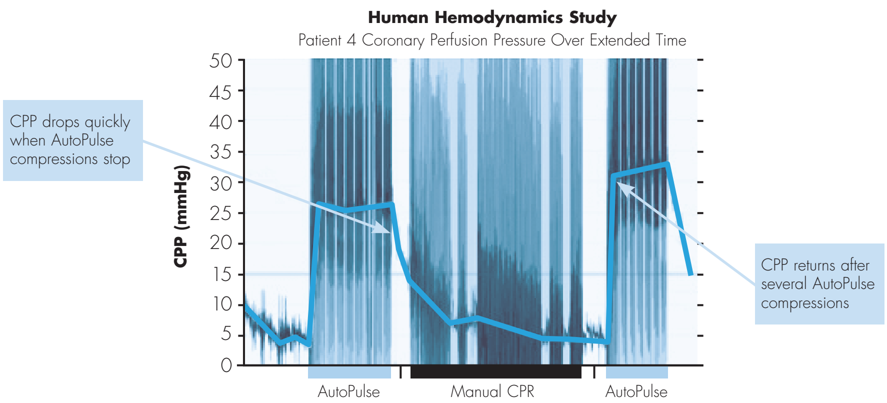
Several recent studies in *Resuscitation* (Foo et al, 2010[5]; Tsou et al, 2009[6]) explored low back pain and the ideal height for performing CPR. While the ideal place for performing CPR is on the floor, this position is not practical in a hospital setting. Still, it is important that the bed be placed in a position that is best for the CPR provider.

Overview of Mechanical CPR

Many centers have begun to include mechanical CPR as part of their resuscitation protocol. The AutoPulse® is a load-distributing band cardiac support pump manufactured and sold by ZOLL Medical. A pilot clinical study of in-hospital cardiac arrests on 31 patients was conducted in 2004 by Timerman et al[7]. After the patient had 10 minutes of failed advanced cardiac life support, the clinicians inserted catheters to measure coronary perfusion pressure with the AutoPulse as well as with manual CPR, and compared the two methods. The AutoPulse created a higher peak aortic pressure, a higher peak right atrial pressure, and a higher coronary perfusion pressure.

Figure 1

Results from Timerman study[6], 2004



The results of the ASPIRE trial, a multicenter randomized trial that compared AutoPulse to manual CPR, were published in *JAMA* in 2006[8]. The study was stopped by the Data Monitoring Safety Board after a secondary endpoint showed poorer neurological outcome in the AutoPulse cohort. The study design used cluster randomization and allowed for changes in protocol in the midst of the study. An analysis by Paradis et al[9] published in 2010 demonstrated that there was a protocol change at one site that appeared to have resulted in a delay in application of AutoPulse-CPR. Before and after the protocol change, survival in patients receiving AutoPulse-CPR decreased from 19.6% to 4% (P = 0.024). Logistic regression analysis showed the site was significantly different (P =0.008) from the remaining sites with respect to survival. The other sites actually showed an increase over time in the primary end point of 4-hour survival (P = 0.008) favorable to AutoPulse-CPR.

In the same edition of *JAMA*, Ong et al[10] reported on their experience with the AutoPulse. In the study, ROSC was used as the primary outcome, while the secondary outcome looked at hospital admission -- survival to discharge -- and neurologic status at discharge. Spontaneous circulation and survival to discharge were greater with the AutoPulse, and if the patient survived to be discharged, there was no neurologic difference between the two groups. Overall, OHCA survival to discharge increased from 2.9% to 9.5%. An update presented at Resuscitation Science in 2009 showed even greater progress with survival to discharge reaching 17%.

A 2007 study by Henning et al[11] followed 46 patients, 54% of whom had return of spontaneous circulation. Of that population, 40% were admitted to the ICU and 21.8% were discharged from the ICU. In this study, the mean time to deploy the AutoPulse was nearly 5 minutes, but the authors demonstrated that, with practice, it could be deployed in 2 minutes. Our experience shows it can really be accomplished in 30 seconds. It is critical that the AutoPulse be deployed as quickly as possible and that CPR not be stopped until the team is ready to put the board under the patient. CPR effectiveness is about minimizing time off the chest, and the same is true with the AutoPulse.

A more recent study in 2009 from Tomte et al[12] used manikins with the primary endpoint of hands-off time and timing of advanced cardiac life support tasks. At the first site, the hands-off time was increased when they used the AutoPulse, because there was a very low hands-off time with manual CPR. The other two sites improved their hands-off time with the AutoPulse. Initial defibrillation was delayed with the AutoPulse. This delay was a deficit of training since resuscitation is a process and the staff needs to be trained to deploy.

In 2010, Ong et al[13] published a before-and-after study on out-of-hospital arrests in the *Annals of Emergency Medicine*. The no-flow time was defined as the sum of all the pauses between compressions that were longer than 1.5 seconds in the first 5 minutes of CPR. In both intervals, manual CPR no-flow time was 85 seconds. With the AutoPulse, the first interval increased to 105 seconds, but the second interval was reduced to 52 seconds. This study supports that training and implementation are critical to success.

Benefits of Mechanical Cardiac Support

The first major benefit of the AutoPulse is that it frees the staff to attend to the patient. When the AutoPulse is compressing, time is available to perform other tasks such as administering medications and other ACLS interventions. It also calms the code. Hands-off time is decreased so that interventions such as defibrillation can still occur while the AutoPulse is compressing.

The AutoPulse also generates near-normal perfusion. A systolic blood pressure of 90 mmHg to 140 mmHg is routinely observed on these patients, as well as a MAP of 50 mmHg to 55 mmHg for most patients who are average in size.

Other benefits include the ability to defibrillate while compressions continue, and decreased work-related and patient injuries as a result of manual CPR.

Convincing an organization to consider the AutoPulse presents some challenges, especially during an economic downturn. However, consider back injuries and the cost associated with them to an organization. There is considerable cost associated with training an ICU nurse who is replacing a nurse recovering from a back injury. Also consider the cost associated with the number of clinicians attending a code. At least three people are needed to do manual CPR during a code because the recommendation is to rotate them every 2 minutes. There are even current studies that suggest three people are not enough; more than 4 minutes of rest is needed to perform another 2 minutes of quality CPR.

Not all interventions available to be implemented have Level I evidence to support them. Medical Center of the Rockies in Loveland, Colorado, evaluated the AutoPulse for three months to assess if it could be used effectively and if it would work in the organization.

EVALUATION AND SUCCESSFUL IMPLEMENTATION

Medical Center of the Rockies, which owns its ambulance service, began its evaluation of the AutoPulse by gaining feedback from the paramedics on the ambulances. They provided positive feedback to the Medical Center. The AutoPulse simplified the process for the paramedics and allowed them to continue CPR while transporting the patient. The clinicians at the hospital asked for an evaluation and implemented it on the Code Blue Team, which is centralized throughout the hospital. The team considered the strategic placement of the AutoPulse, which is critical, discussing where to place the device and if a device should be placed on each unit. Other considerations included staffing and training, as well as the size of the facility. Medical Center of the Rockies consists of two hospitals; one with 236 beds and one with 136 beds. Based on the size of the facility, they decided to deploy with the centralized Code Team and locate the AutoPulse in the ICUs, where the majority of the codes occur.

The following are the key points that will enable hospitals to have a successful AutoPulse experience:

1. **Choose a strategic location where routine checks can be conducted.** Just as routine checks on code carts are critical, so are routine checks on the AutoPulse. If you have only one AutoPulse, chose a location where the number of codes is the most frequent and where AutoPulse placement will be the most beneficial.

2. **Plan to be able to move the AutoPulse within the hospital.** At Medical Center of the Rockies, the AutoPulse is mounted under the ZOLL defibrillator on a pole that travels with the Code Blue Team. It has a handle on the side to facilitate pushing or pulling as well as a key to the elevator for speed to access to the patient. One person on the Code Team is responsible for the cart and is the first person activated through the Code Team call system in hopes the cardiac ICU nurse has a head start. The team's response time is 3 to 5 minutes, depending on where the code occurs in the hospital.

Figure 2: AutoPulse Transport:
- Mounted below defibrillator
- Handle to facilitate pulling or pushing
- Taken with in-house team when activated
- Keys to elevator

3. **Define your patient population.** The AutoPulse has contraindications, such as trauma patients because they could be bleeding internally and the AutoPulse could exacerbate the problem. Medical Center for the Rockies also does not use the AutoPulse on patients who have had aneurysm repairs in their abdomen, where clinicians cannot see if they are bleeding. Other restrictions include pregnant women, children under 18, and patients who weigh less than 85 pounds. It is a challenge to use the AutoPulse on patients who weigh more than 350 pounds because the band may not go around them. Medical Center for the Rockies restricts its use with patients with unstable C-spines.

4. **Define equipment management responsibilities.** To successfully use the AutoPulse, a clear definition of who maintains the batteries is critical. Medical Center of the Rockies changes the battery every day to ensure it is ready when needed. A check that the hygiene barrier is on the board is also recommended.

Develop a Procedure

- Define what patient populations can and cannot use the AutoPulse
- Assign who places the patient on the device
- Clearly define how to use the AutoPulse and how to clean it after use
- Clearly define how to change the LifeBand
- Documentation regarding AutoPulse during a code
- Daily Maintenance:
  - Check LifeBand
  - Check hygiene barrier
  - Change battery

5. **Train, train, and retrain.** In our experience, training and quarterly retraining are critical to success. Unless clinicians use the AutoPulse frequently, their skill levels for deployment as well as their comfort level diminish dramatically.

6. **Develop a standard process to deploy the AutoPulse.** For example, if a patient is on an air bed and is turned, an indent is created where the patient was lying. The AutoPulse, because of its weight, will sink in the indent, making it difficult to turn the patient back onto the AutoPulse. The best way to deploy on an air bed is to sit the patient up, slide the board under the patient, and then lay the patient flat. Another technique is to use a small, thin sheet that patients have underneath them. By using the sheet, the patients can be sat upright and positioned properly on the board, then the sheet is pulled down under the LifeBand. It has been observed that when a patient who is in cardiac arrest on the AutoPulse is cold and clammy, they have a tendency to stick to the AutoPulse. Therefore it is important to position them correctly from the start. Medical Center of the Rockies also recommends deploying the AutoPulse quarterly on an actual person rather than on a manikin because of the weight differential.

Simulate Placement of the AutoPulse

- Use a person, not a manikin, to simulate actual weight (remove the battery as a precaution)
- Drill often, at least quarterly
- Practice precision and placement in less than 30 seconds (time the drill)
- Standardize the process

At Medical Center of the Rockies, deploying the AutoPulse under the patient is not the emergency. The emergency is making certain the clinician is performing good manual CPR. There should be a board under the patient and someone performing good manual CPR that is producing a pulse. It is also important to know the initial rhythm. At Medical Center, if a patient is in ventricular tachycardia or ventricular fibrillation, the placement of the AutoPulse is not attempted before a first shock is given. The protocol states to defibrillate, then provide 2 minutes of manual CPR before starting AutoPulse deployment.

Provide a standard procedure that clinicians practice, as well as a short video of a mock code so that the clinicians can watch themselves. Timing a clinician's hands-off time is also a very effective tool for learning and improving. Medical Center of the Rockies, due to quarterly practices, now can deploy the AutoPulse in 30 seconds. Every quarter, a mock code using the AutoPulse is performed to make certain the clinicians stay competent at deployment. They focus on the fact that pauses should be kept to a minimum, and practice scenarios such as, What do you say to the doctor who's taking too long to intubate? What are you going to say to the doctor who wants to keep pausing to defibrillate and you haven't done 2 minutes of CPR? Part of resuscitation is teamwork and communication, and therefore team training is critical.

AutoPulse Placement Procedure

- Start manual CPR. Placement of the AutoPulse does not need to be immediate.
- Remove the AutoPulse from the transport device and turn it on.
- Continue manual CPR. Have staff position themselves on each side of the patient.
- When everyone is in position and ready, the person with the AutoPulse counts.
- On the count of 3, lift the patient into a sitting position, and slide the AutoPulse in behind the patient.
- Lower the patient onto the AutoPulse. Ensure positioning is appropriate, and bring the LifeBand around chest.
- Pull up the LifeBand, start the AutoPulse.

Once the AutoPulse is turned on and running, a 10-second pause at the 2-minute time point is used to view the rhythm. As soon as the rhythm appears, the AutoPulse is started again, and if the rhythm is shockable, defibrillation happens as the AutoPulse is compressing.

Figure 3: Pausing AutoPulse:

- Pauses should be kept to a minimum, checking for a shockable rhythm
- When shock is advised, the AutoPulse can continue compressions during the shock

Survival to discharge data:

Year	Number of Actual Codes	Codes with AutoPulse	Initial Rhythm		Survival to Discharge
			PEA/Asystole	VT/VF	
2007	45	19 (42%)	53% (24/45)	16% (17/45)	43% (17/40)
2008	33	14 (42%)	76% (25/33)	6% (2/33)	33% (9/27)
2009	58	25 (43%)	64% (37/58)	31% (18/58)	44% (21/48)

This is based upon the survival-to-discharge data. By definition, a code for Medical Center of the Rockies consists of a patient who receives CPR or is defibrillated, or a respiratory arrest that is intubated. Codes have ranged from 33 to 58 patients annually since 2007. The AutoPulse has been deployed approximately 42% of the time, usually in longer codes with patients presenting with PEA/asystole rhythms. The majority of Medical Center codes are PEA/asystole, not shockable ventricular tachycardia or ventricular fibrillation; therefore the survival to discharge ranges from 33% to 44%. Eighty-five percent of codes occur in the ICU.

The AutoPulse is one component of a bundle that has improved survival to discharge at Medical Center of the Rockies. In addition to the AutoPulse, a pharmacist was added to the Code Blue Team -- only 30% of hospitals have a pharmacist on their team. It has been has shown that 18 more patients survive per hospital if there is a pharmacist on the code team. If projected to all the hospitals in the country, 67,000 lives would have been saved (1999 data). Imagine what it would be today.

The training of the Code Team was increased to include more simulation training with placement of the AutoPulse. The Rapid Response Team is quite active and transfers most of the patients into the ICU. Approximately 15% of the codes occur inside the ICU. Finally, induced hypothermia on any patient who has arrested and does not regain consciousness is also part of the bundle.

- The AutoPulse was used with a hypertrophic cardiomyopathy patient from amyloidosus. The AutoPulse was compressing at 80 compressions per minute but not producing a pulse on the arterial line. The AutoPulse is only compressing, it needs to have a heart that is full of blood to be effective. In this case, the patient needed blood volume and vasoconstricting drugs before a pulse could be generated. All these factors are required for the patient to have a successful resuscitation.

- The movement the AutoPulse creates makes it difficult to feel femoral pulses, which is the usual place to palpate pulses in a code. Checking the carotid for a pulse instead is more effective. The AutoPulse actually produces enough systolic pressure that it is possible to feel a brachial pulse or a radial pulse as well. Arterial lines have shown the AutoPulse can create a systolic blood pressure of 140 mmHg.

- The AutoPulse can create slight pulmonary edema that can be seen in the ET tube on some patients, usually smaller patients. As soon as the code has ended and the AutoPulse is turned off, the pulmonary edema will disappear. There have not been any post-code issues with this situation, but it is important to be aware of it.

- At Medical Center of the Rockies, the AutoPulse has been used on open-heart surgery patients several times, and many of these patients have had their chests opened afterward. None of the grafts has been disrupted. The difference between the heart surgery patient and the abdominal aneurysm patient is that they have chest tubes. A general rule for the nurses is to check the chest tubes as the AutoPulse is deployed. If there is more bleeding, undo the LifeBand. If the patient is not bleeding, deploy the AutoPulse because it will keep the patient alive until the heart surgeon arrives. The heart surgeons have conveyed that the AutoPulse compresses more gently on the sternum, because of its circumferential compressions, than when clinicians perform CPR manually.

- A 53-year-old patient collapsed at home after returning from an operation. He was in ventricular fibrillation. He received 10 minutes of manual CPR and 27 minutes with the LUCAS™ device because that is what the Loveland paramedics use, and then received 60 minutes of chest compressions with the AutoPulse when he arrived at Medical Center of the Rockies. He went to the Cath lab, had his LAD stented, and left with a balloon pump and vasopressin administered. He arrested several more times in the ICU. Hypothermia was induced for 24 hours. Then he was re-warmed over 12 hours. The ICU nurse caring for him asked: "Joe, give me a thumbs up. We need to know you're in there." And Joe did. The nurse asked, “Joe, show me two fingers so I really know you’re in there,” and Joe did. That was in mid-November. Joe came back in December to share some treats with the nurses and made sure everyone knew he was doing okay.

- A male patient was at home and experienced an SCA. No CPR was administered at home, but, luckily, he lived next to a fire station. He was brought in by an ambulance on the AutoPulse. The AutoPulse was deployed for 35 minutes. He was determined to have a STEMI and was taken to the Cath lab, where his LAD was opened and hypothermia was induced. The patient was revived and had a full neurologic recovery.

Conclusion

A recent study in 2010 in *Critical Care Medicine* by Meaney et al[14] states that if patients have PEA/asystole, 12% of them will survive; for VT-VF, the number rises to 37%; and overall, somewhere between 0 and 29 percent survived to discharge. For Medical Center of the Rockies, since the bundle (including AutoPulse) was implemented, the normal survival of 15% to 21% rose to 33% to 44%. Using a bundle of interventions, including the AutoPulse, to resuscitate patients can significantly change patient outcomes.

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