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AutoPulse®
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Clinical Review of Cardiac Arrest, CPR Efficacy, and the AutoPulse

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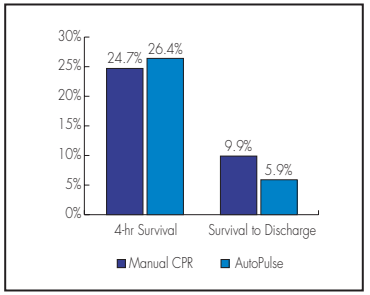
Short & Long-term Survival Study: University of Washington[14]

- ASPIRE : AutoPulse Pre-hospital International Resuscitation
- Cluster Randomized, Multi–center Trial
- 1,071 patients enrolled, however primary comparison was made with 767 cases identified as cardiac in nature.
  - 373 patients treated with manual CPR
  - 394 patients treated with the AutoPulse

p = 0.062 p = 0.053



Conclusions:

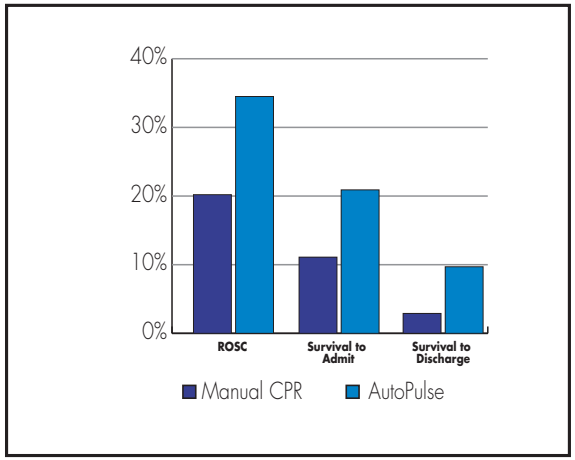
The results of the study were inconclusive and did not reach statistical significance.

The study suffered from implementation and study design problems including the following:

- Very late use of the AutoPulse (average of 12 minutes after 911 dispatch)
- Patients in the AutoPulse arm were defibrillated approximately 2 minutes later than the manual CPR group
- Inconsistent training and monitoring of EMS
- Allowed for multiple protocols; one site that changed protocols had a disproportionate impact on the combined data from all five sites

Long-term Survival Study: Virginia Commonwealth University[13]

- Compared survival rates in 783 patients in the pre-hospital setting
  - 499 patients treated with manual CPR
  - 284 patients treated with the AutoPulse
- 71% improvement in field ROSC from **20.2%** to **34.5%** p = 0.0001
- Survival to hospital admission rose from **11.1%** to **20.9%** p = 0.0002
- Survival to discharge rose from **2.9%** to **9.7%** with AutoPulse p = 0.0001



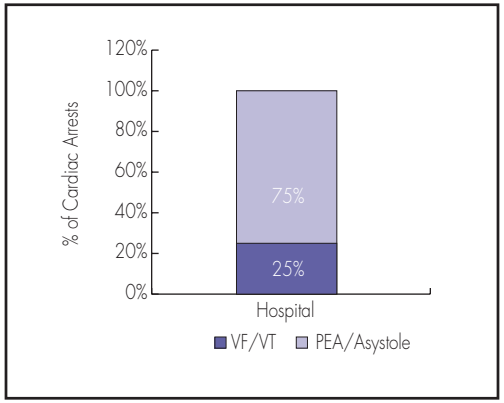
Conclusions:

Results of this study suggest that a strategy employing AutoPulse CPR on rapidly responding EMS ambulances improves survival to hospital discharge in adult out-of-hospital cardiac arrest victims.

INTRODUCTION:

It is well established that the incidence of survival from cardiac arrest, both out-of-hospital and in-hospital is poor. With more than 400,000 deaths from cardiac arrest annually, the challenge of improving outcomes is substantial.

The National Registry of Cardiopulmonary Resuscitation (NRCPR) and other out-of-hospital studies indicate that the incidence of arrest associated with asystole and pulseless electrical activity (PEA) is higher than originally thought and due to progressive respiratory failure and shock rather than arrhythmias. Hospital data shows an incidence of 75%.[1]



These non-shockable etiologies traditionally have much poorer outcomes and have increased attention to the role of CPR in conjunction with and in lieu of early defibrillation. The new AHA 2005 Guidelines for CPR and ECC reflect this emerging data and feature a renewed emphasis on CPR.

EFFECTIVE CPR IS VITAL TO SURVIVAL OF IN-HOSPITAL ARREST

The latest report on the NRCPR findings demonstrated that children survive to hospital discharge more frequently following in-hospital arrest predominately because of better outcomes following asystole and PEA, while adults tend to have better outcomes in the arrests associated with VF and VT. This finding in children may reflect the belief that children rarely suffer a VF/VT arrest and therapy is focused on CPR, where as in adults the opposite is believed and emphasis has been place on early defibrillation therapy to the detriment of early and effective CPR.

Surprisingly, the incidence of VF/VT arrest in children is actually higher than previously believed, though still far less than asystole and PEA. And even more to the point, the incidence of asystole and PEA arrest in adults in hospital is much higher than originally believed.[2]

RESUSCITATION: THE EVOLVING RELATIONSHIP OF CPR AND DEFIBRILLATION

Originally, resuscitation was best characterized by the Chain of Survival, which gave defibrillation and CPR equal status on the chain. Defibrillators were not widely deployed so time to shock was long and survival extremely poor. In this setting CPR was critical to survival success.

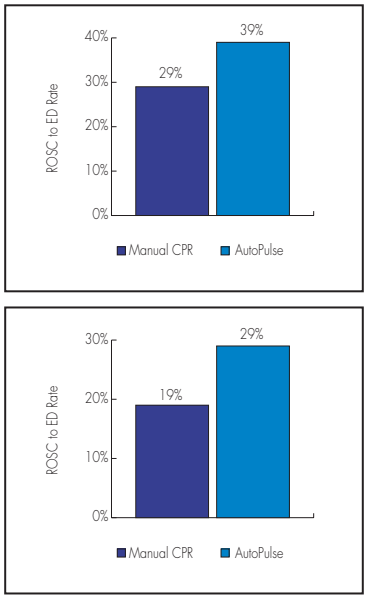
During the 1990's, as defibrillator deployment expanded widely and AEDs began to be distributed, the educational and therapeutic focus shifted to early defibrillation and time to shock – often to the detriment of CPR given the prevalence of non-shockable rhythms. Thus, it has been speculated that survival statistics failed to improve as greatly as expected.

Beginning with the 2000 Guidelines and now even more so with Guidelines 2005, we have come full circle back to the realization that CPR is equally important, and in many cases may be preeminent.

EVAC Ambulance Volusia County FL[11]
University of California San Francisco and San Francisco General Hospital[12]

Two studies compared patients treated with manual CPR to patients treated with AutoPulse to determine the impact of AutoPulse on the delivery of patients with sustained ROSC to the Emergency Department. A total of 685 patients were enrolled.

n = 93 n = 69 n = 405 n = 118



p = 0.02 p = 0.003

Conclusions:

The AutoPulse may improve the overall outcome likelihood of sustained return of spontaneous circulation and may particularly benefit patients with non-shockable rhythms.

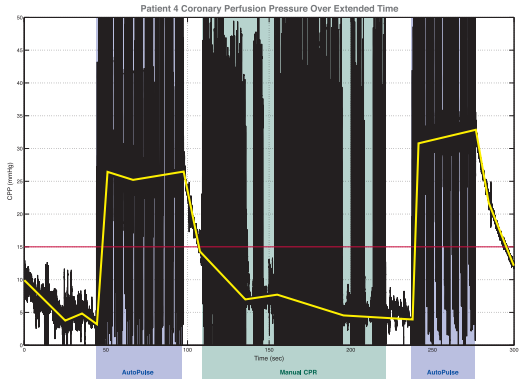
This study was limited by its size, lack of data on long-term survival and non-randomized design. Despite these limitations, treatment with AutoPulse showed a significant increase in short-term survival and in patients with non-shockable rhythms.

HUMAN STUDIES

Human Hemodynamic Impact Study – University of Sao Paulo Brazil[10]

- 16 terminally ill subjects who arrested in-hospital
- Catheters were inserted to measured Peak Aortic pressure and Right Atrial Pressure in order to calculate CPP
- Alternated AutoPulse and manual CPR - 90 seconds each
- Initiated post 10 minutes of failed ACLS ~ 30 min elapsed between code and initiation of study due to need for instrumentation
- 33% improvement in CPP with AutoPulse despite long delay
- One patient experienced ROSC

The chart below shows a coronary perfusion pressure chart over time and the rapid drop off in CPP when the AutoPulse is removed and switched to manual CPR and the increase in CPP when AutoPulse is turned back on following manual CPR. The red line denotes the 15mmHg CPP line – the minimum pressure for return of ROSC.



Guidelines 2005:

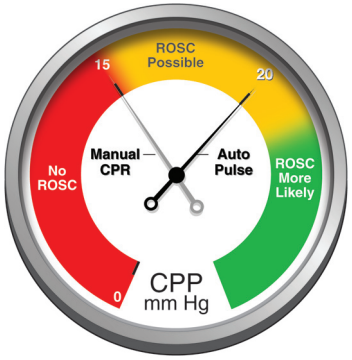
" CPR is important both before and after shock delivery. When performed immediately after collapse from VF SCA (sudden cardiac arrest) CPR can double or triple the patient's chance for survival. … After about 5 minutes of VF with no treatment, outcome may be better if shock delivery (attempted defibrillation) is preceded by a period of CPR with effective chest compressions that deliver some blood to the coronary arteries. CPR is also important immediately after shock delivery; most victims demonstrate asystole or PEA for several minutes after defibrillation. CPR can convert these rhythms to a perfusing rhythm.

Not all adult deaths are due to SCA and VF. An unknown number have an asphyxial mechanism… Studies in animals have shown that the best results for resuscitation from asphyxial arrest are obtained by a combination of chest compressions and ventilations, although chest compressions alone are better than doing nothing."

"Sadly we have learned that bystander CPR is performed in only about one third of witnessed arrests or fewer and that when CPR is performed, even by professionals, it is often not done well. Excessive ventilation is provided during CPR for victims with advanced airways, with a resulting decrease in cardiac output, compressions are interrupted too frequently with a resulting drop in coronary perfusion pressure and chest compressions are often too slow and too shallow."[3]

CPP and ROSC

A landmark early human study by Paradis et al[4] examined the role of Coronary Perfusion Pressure (CPP) in the Return of Spontaneous Circulation (ROSC). Coronary Perfusion Pressure is defined as the difference between aortic pressure between compression and right atrial pressure. The findings were startling in that **no** patient experienced ROSC unless CPP was greater than 15mmHg, and the higher the pressure the greater the likelihood of ROSC. While some patients with higher CPP did not experience ROSC, in general the correlation was excellent.



CPP Gauge

ROSC IS HIGHLY CORRELATED WITH CPP AND THUS SURVIVAL

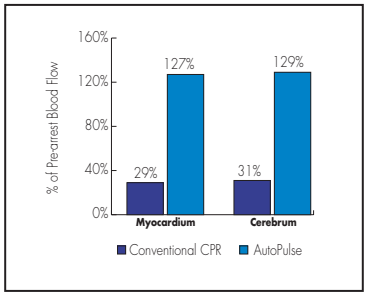
A study by Timerman et al[5] demonstrated that manual chest compressions even when delivered by experienced well-trained providers were unlikely to consistently exceed CPP of 15mmHg – perhaps pointing toward the abysmal failure to resuscitate adults with asystole and PEA as compared to VT and VF. Manual compressions in the face of these non-shockable rhythms may simply be unable to reach consistent sufficient CPP levels to support ROSC.

Animal Hemodynamic Study: Johns Hopkins University Medical Center[9]

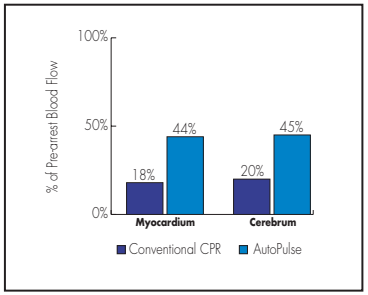
- Objective: evaluate the comparative hemodynamic impact in both a BLS and ACLS model (with epinephrine)
- 20 pigs with 1 minute VF
- Regional cerebral and myocardial blood flow measured with neutron-activated microspheres

Results:

ACLS Protocol:



BLS Protocol:



Conclusions:

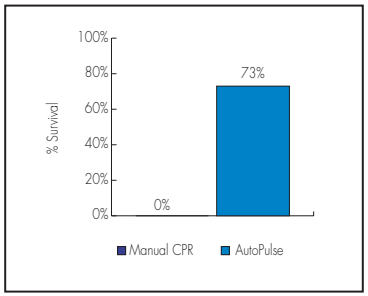
"In this pig study, AutoPulse CPR with epinephrine produced pre-arrest levels of myocardial and cerebral blood flow. The improved hemodynamics appear to be due to airway collapse, which likely impedes airflow and helps to maintain higher levels of intra-thoracic pressure.

Because survival from cardiac arrest, when defibrillation fails or is not indicated, is related to the amount of blood flow generated by CPR, it is likely that AutoPulse CPR, if used early enough in the course of cardiac arrest could improve survival."

ANIMAL STUDIES

Animal Survival Study: Stanford University Medical Center[8]

- Objective: Evaluate the ability of AutoPulse to affect survival
- Used a clinically relevant pig cardiac arrest model:
  - 8 min VF
  - 4 min BLS
  - 4 min ALS
  - n = 30
- End-points were ROSC, 24-hour survival and neurological status at 24-hours
- CPR treatment was randomized to AutoPulse or conventional CPR ("The Thumper")



Result:

There was no survival in the conventional CPR group. The AutoPulse cohort experienced 73% survival and 88% of the survivors were found to be neurologically normal.

CPR EFFICACY IS NOT ONLY A MATTER OF TRAINING

A study of CPR efficacy conducted by Abella et al[6] demonstrated that even in a university setting with well-trained providers, manual CPR fell far short of the guideline recommendations. The study measured CPR efficacy in the first 5 minutes of arrest and found the following about manual compressions:

- Slow – less than 90/minute in 28% of measured 30 second segments during the first 5 minutes of CPR
- Shallow < 38mm of 37.4% of measured segments
- Interrupted and Tiring
- Analysis of time with arrest but without compressions yielded a mean of .24 of the period
- 40.5% of 30 second segments had no flow periods > 0.20
- Despite a small sample size (n=67) periods of 'no flow' approached statistical significance with regard to ROSC

AHA GUIDELINES 2005: CPR

"Simply put: rescuers should push hard, push fast, allow full chest recoil, minimize interruptions in compressions…"

"LDB(Load Distributing Band) CPR may be considered for use by properly trained personnel as an adjunct to CPR for patients with cardiac arrest in the out-of-hospital or in-hospital setting (Class IIb)."[7]

In light of these findings and recommendations, it is believed that a new way to provide improved CPR in the hospital, particularly in the face of the high incidence of asystole and PEA, is critically needed. The new ZOLL AutoPulse® is the first commercially available load-distributing band for use in the management of cardiac arrest. The following pages will review the product and the body of clinical data supporting its efficacy.

AUTOPULSE: CONSISTENT COMPRESSIONS. UNINTERRUPTED.

Fast, Easy and Intuitive:

The AutoPulse is a comprehensive resuscitation platform that has the power to transform the way CPR is performed by medical professionals.

The AutoPulse Non-invasive Cardiac Support Pump pumps the patient's chest to circulate blood to the heart, brain and other vital organs during cardiac arrest treatment. It allows clinicians to focus on complementary interventions such as drugs, ventilation and defibrillation, greatly enhancing the resuscitation process for rescuers in and out of the hospital.

The user interface is extremely intuitive and simple.

The AutoPulse automatically sizes the patient, calculating size, shape and compliance – there is no need to enter patient information or make manual adjustments.

Like an Additional Person

The AutoPulse functions as an extra person, freeing clinicians to perform other critical tasks. But more importantly, it pumps consistently and rapidly as outlined in the guidelines. Most of all, AutoPulse doesn't get weary – it will deliver the same consistent compression at minute 15 as it delivered at minute one.

CLINICAL RESULTS

EFFICACY AND THE PROMISE OF IMPROVED BLOOD FLOW

The AutoPulse provides consistent, hands-free compressions, and provides both thoracic and cardiac compression and return for maximal forward flow and coronary filling.

Animal and human studies in support of the AutoPulse are reviewed on the pages that follow.