TRANSLATING 2007 RESUSCITATION RESEARCH INTO PRACTICE

By Judy Boehm, RN, MSN

Every year in November the American Heart Association (AHA) holds its Scientific Sessions, during which basic, clinical, and population research is presented. Additionally, the Resuscitation Science Symposium (ReSS) is held in the days before. The ReSS is an international forum for fundamental, translational, clinical and population scientists and care providers to discuss recent advances related to treating cardiopulmonary arrest and life-threatening traumatic injury. Below I will share with you some of the research studies that were presented on the topic of resuscitation so that you can evaluate them and consider applying new knowledge and techniques to your clinical practice at the front lines of patient care. Abstracts of these studies can be found in *Circulation 2007, volume 116, supplement II*. The number following the title is that assigned to the abstract, as listed in Circulation.

Many of the studies presented below are from the National Registry of Cardiopulmonary Resuscitation (NRCPR) and the Resuscitation Outcomes Consortium (ROC). The NRCPR® is an international database of in-hospital resuscitation events sponsored by the American Heart Association and managed by Digital Innovation, Inc. Initiated in 2000, the NRCPR now contains greater than 100,000 resuscitation events from over 430 participating hospitals in the US, Canada, Germany, Japan, and Brazil. Not only does the NRCPR track cardiopulmonary arrest events, but also acute respiratory compromise events and Medical Emergency Team events. The Mission of the NRCPR Hospital Safety Program is to reduce disability and death from cardiac and respiratory emergencies by providing an evidence-based, quality improvement program of patient safety, medical emergency team response, effective resuscitation, and post-emergency care. The data collected by NRCPR (with consistent definitions) originates from the standardized guidelines for reporting in-hospital resuscitation events, found in the scientific statement *Recommended Guidelines for Reviewing, Reporting, and Conducting Research on In-Hospital Resuscitation: The In-Hospital 'Utstein Style'*, which can be accessed at: http://circ.ahajournals.org/cgi/content/full/95/8/2213

The Resuscitation Outcomes Consortium (ROC), which was founded in 2006, conducts collaborative clinical trials of promising new treatments for cardiac arrest and severe traumatic injury. Along with EMS agencies, ROC involves public safety agencies, regional hospitals, community healthcare institutions and medical centers in 11 regions in the United States and Canada, which are shown in Figure 1.

Figure 1 Resuscitation Outcomes Consortium (ROC) Sites

One of ROC's initial efforts is the formation of the Epistry Database, an epidemiologic databank of out-of-hospital cardiac arrest and life threatening trauma cases that also reports in-hospital outcomes. Below you will find the earliest research studies originating from Epistry.

Research Studies Related to Optimizing Cardiopulmonary Resuscitation (CPR) Technique

Incomplete Chest Recoil During Piglet CPR Worsens Hemodynamics (30) Zuercher, M. et al. Sarver Heart Center, Tucson, AZ

Aim: To determine the effect of incomplete chest recoil (10% and 20% lean on the chest during decompression) on hemodynamics during piglet CPR.

Methods: After 10 piglets were anesthetized and instrumented with right atrial and aortic catheters, ventricular fibrillation (VF) was induced. CPR was provided in 3-minute periods with no lean, 10% lean, or 20% lean while aortic systolic pressure (AoS) was maintained at 80-90 mmHg.

Results: 10% and 20% lean resulted in higher right atrial diastolic pressure (RAD) and lower coronary perfusion pressure (CPP) than no lean. Hemodynamics were not different for 10% vs. 20% lean. Mean 10-20% lean resulted in substantially lower left ventricular myocardial blood flow (MBF) and cardiac index (CI) than no lean.

Lean	AoS (mmHg)	RAD (mmHg)	CPP (mmHg)	MBF (ml/min/g)	CI (L/min/m^2)
None	87±4	9±1.9	22±5.4	0.40±0.34	1.8±0.77
10%	86±4	11±1.7*	19±6.6*	0.24±0.22	1.2±0.59
20%	87±5	13±2.7*	17±6.4*	0.19±0.12	1.0±0.31

* Statistically significant

Conclusion: Results indicate that leaning on the chest during decompression significantly reduces forward blood flow during CPR.

Responders should be coached in full recoil during training and during resuscitations. Could technologic methods be devised to provide feedback on recoil during CPR? A helpful scientific study using manikins that investigated alternative hand positions that might improve full decompression is:

Aufderheide, T.P. et al. Incomplete chest wall decompression: A clinical evaluation of CPR performance by trained laypersons and an assessment of alternative manual chest compression-decompression techniques. *Resuscitation* 2006;71:341-351.

CPR Fraction Prior to Defibrillation Determines Survival in Prehospital Cardiac Arrest in the ROC Epistry (5) ROC Researchers

Aim: To estimate the effect of the 2005 American Heart Association (AHA) Guidelines related to increasing CPR fraction (proportion of resuscitation time with active CPR) on survival in a cohort of patients with out-of-hospital (OOH) VF or ventricular tachycardia (VT).

Methods: Patients were selected from the ROC Registry who had confirmed VF/VT cardiac arrest that was not witnessed by Emergency Medical Services (EMS), received no public access defibrillation shock prior to EMS arrival, and had impedance recordings of CPR before the first shock. The proportion of each minute (calculated for minutes 1, 2, 3, 4 and 5) with active CPR, from defibrillator pad application until the first shock, was measured from the electronic resuscitation record.

Results: Of 7963 EMS-treated cases of cardiac arrest without public access defibrillation, 1893 had an initial rhythm of VF/VT and 283 of those had electronic tracings and confirmed outcome. Bystanders performed CPR on 51% and 41% arrested in a public location. As seen in the table, increasing CPR fraction is associated with increased survival from VF/VT arrest.

CPR Fraction	0-20%	21-40%	41-60%	61-80%	81-100%
Number	70	46	56	73	38
Survived to discharge (%)	6 (8.6%)	10 (21.7%)	11 (19.6%)	20 (27.4%)	13 (34.2%)
Adjusted odds ratio (95% CI)		4.38 (1.11, 17.28)	2.04 (0.52, 8.02)	3.45 (0.90, 13.23)	3.60 (0.87, 14.89)

Conclusion: This study provides preliminary evidence that minimally interrupted CPR has a direct clinical impact on survival after VF cardiac arrest. Limitations of this study include that it was observational, relatively small, and CPR fraction was only able to be monitored after pad application.

Dr. Lance Becker, director of ReSS, interviewed Dr. Clifton Callaway from the University of Pittsburgh, one of the investigators in this study, about implications of this research. This interview can be found at: http://www.heart.org/presenter.jhtml?identifier=3051667 I liked his image of thinking of compressions as the patient's heartbeat, in that you don't want it to stop. During a resuscitation the whole team should work around the rescuer providing compressions so that compressions are continuous and not stopped. Callaway stated that interruptions in CPR are as great a factor in contributing to survival as is witness status.

Audio Analysis of Pauses during CPR Delivered by Hospital Responders (1805) Wallbrecht, J.L. et al. University of Chicago, Chicago, IL & University of Pennsylvania, Philadelphia, PA

Aim: To characterize the etiology and duration of pauses in chest compressions as administered by health care providers during actual resuscitations in the hospital. Also to test the hypothesis that pauses for pulse checks are longer than for other pause etiologies.

Methods: A prospective, observational study was conducted using a commercially available monitor/defibrillator with CPR and audio recording capabilities (Philips MRx) during in-hospital cardiac arrests at a tertiary care medical center from 4/2006 until 8/2006. The audio recordings from each pause in chest compressions were transcribed. Etiology of the pause was determined by 3 independent investigators.

Results: Audio recordings from 109 total pauses were analyzed from 12 consecutive arrests containing discernable audio transcripts with a mean pause time of 13.8$\pm$9.3 seconds, and an average of 9$\pm$6 pauses recorded per arrest. Pulse checks were noted in 44% of the pauses. Pauses for pulse checks were significantly longer than for other reasons (16.1$\pm$10.4 seconds vs. 12.1$\pm$7.8 seconds; p=0.03). Etiologies for other pauses were related to defibrillation, intubation, rescuer rotation, and central line placement.

Conclusions: Human performance issues during CPR, such as difficulty with pulse evaluation, affect resuscitation quality. Pauses can affect hemodynamics and influence the outcome of resuscitation.

This underscores the need for objective monitoring and reporting of CPR delivery during resuscitations. Could feedback be provided once pauses exceed 3-5 seconds to help providers become aware of and minimize pause duration? Rescuers should be taught that if there is a question about the presence of a pulse, compressions should be resumed immediately. Are there technical means for monitoring pulsations that could be used to minimize these pauses?

Quality of Cardiopulmonary Resuscitation before and during Transport in Out-of Hospital Cardiac Arrest (24) Olasveengen, T.M. et al. Ulleval University Hospital and University of Oslo, Oslo, Norway

Aim: To evaluate the quality of CPR performed during transport after out-of-hospital (OOH) cardiac arrest.

Methods: This was a retrospective, observational study of all non-traumatic cardiac arrest patients older than 18 years who received CPR both before and during transport between May 2003 and December 2006 from the community run EMS system in Oslo. Chest compressions and ventilations were detected from impedance changes in routinely collected ECG signals. The hands-off ratio was calculated as the time without chest compressions divided by the total CPR time.

Results: 75 of 787 consecutive OOH cardiac arrest patients met the inclusion criteria. Quality data were available from 36 of 66 patients receiving manual CPR and 7 of 9 receiving mechanical CPR. CPR was performed for a mean 21±11 minutes before and 12±8 minutes during transport. Hands-off time intervals significantly increased and compressions/minute significantly decreased when comparing CPR during transport to on-scene CPR; see table below. Compression and ventilation rates were unchanged. Quality was significantly better with mechanical than manual CPR. Four patients (5%) survived to hospital discharge; 2 with manual CPR [Cerebral Performance Categories (CPC) 1 and 2], and 2 with mechanical CPR [CPC scores 3 and 4]. No discharged patients had any spontaneous circulation during transport.

Quality of CPR Measurements for those with Manual Compressions (n=36)

Quality Measurement	Entire Episode	Before Transport	During Transport	P value
CPR time (min)	33±13	21±11	12±8	0.001
Hands-off ratio	0.22±0.09	0.19±0.09	0.27±0.15	0.002
Compression rate	118±9	118±11	119±11	0.697
Compressions/min	89±13	94±14	82±19	0.001
Ventilation rate	13±4	13±4	14±3	0.267

Conclusion: Quality of CPR decreased during transport. Thus, every effort should be made to stabilize patients on-scene before transporting to the hospital. It should be noted that resuscitation of patients who had ongoing CPR during transport was not futile.

These findings would also apply to arrests occurring in public areas of hospital, so that resuscitation efforts should continue on site until the patient is stable for transport. See the opening section of the Code Communications newsletter from December, 2007, on "How Should I Adjust the Performance of CPR When the Victim is in a Public Area of the Hospital?"

End-tidal Carbon Dioxide ($EtCO_2$) as a Measure of CPR Efficacy during Human Cardiac Arrest (1806) Wallbrecht, J.L. et al. University of Chicago, Chicago, IL & University of Pennsylvania, Philadelphia, PA

Aim: To test the hypothesis that $EtCO_2$ levels positively correlate with improved chest compression rate and depth during human cardiac arrest.

Methods: A prospective, observational study was conducted using a commercially available monitor/defibrillator with CPR quality and $EtCO_2$ sensing capabilities (Philips MRx) during in-hospital cardiac arrests at one hospital from 4/2006 until 8/2006. Resuscitation transcripts were divided into 30-second segments and mean values of chest compression rate and depth and $EtCO_2$ were derived for each segment.

Results: Data were collected and analyzed from 281 30-second segments with a median of 12 segments per arrest from 13 consecutive patients. Mean $EtCO_2$ was 19 ± 7 mmHg. After adjusting for compression rate and clustering, there was a positive correlation between compression depth and $EtCO_2$ (regression coefficient 0.20). There was no significant correlation between compression rate and $EtCO_2$ after adjusting for compression depth and cluster, nor between survival and $EtCO_2$ levels.

Conclusion: Deeper chest compressions correlated with higher $EtCO_2$ levels. Based on this relationship, changes in $EtCO_2$ during the actual resuscitation event may be reflective of the CPR quality being delivered. Perhaps continuous monitoring of $EtCO_2$ during CPR can be used to ensure resuscitation quality.

Good quality CPR results in improved patient hemodynamics and leads to better survival. Components of quality CPR are being defined, and means to assess these components objectively are being derived. Use of feedback devices and physiologic measurements during resuscitations can be used to improve quality. How is your hospital assessing quality of CPR and helping health care providers improve their CPR technique?

Research Studies Related to Defibrillation

Impact of Delayed Time to Defibrillation on Neurological and Functional Status Among Survivors of In-hospital Cardiac Arrest (23) Chan, P.S. et al. University of Michigan, Ann Arbor, MI

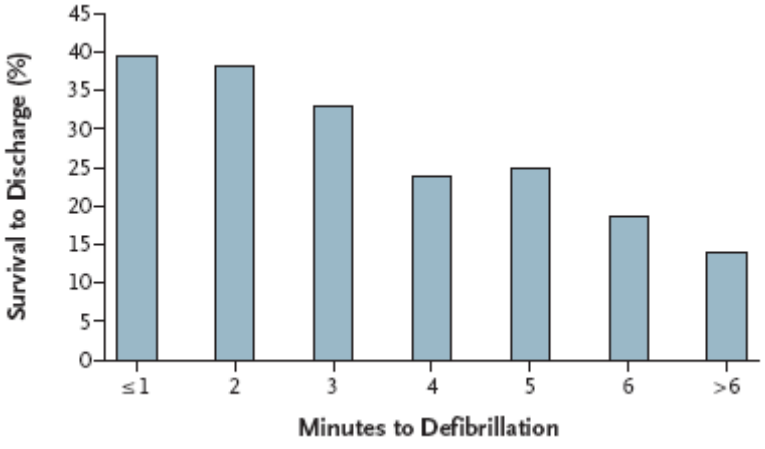
Aim: Expert guidelines advocate defibrillation within 2 minutes of an in-hospital cardiac arrest due to VF. The aim of this study is to describe how time to defibrillation in hospitalized patients relates to neurological and functional status. Much of the previous data about time to defibrillation and outcomes has been written about the out-of-hospital setting.

Methods: 6744 patients with cardiac arrest due to VF or pulseless VT at 369 hospitals within the NRCPR were identified. Patients were 18 years of age or older, and the arrests occurred in intensive care units or inpatient beds. The association between delayed defibrillation (>2 minutes) and neurological and functional status at discharge was examined using Cerebral and Overall Performance Categories.

Results: The median time to defibrillation was 1 minute (interquartile range: <1 to 3 minutes), with delayed defibrillation found in 2000 (29.7%) patients. Overall, 2311 (34.3%) patients survived to hospital discharge; 1863 (39.3%) survived with prompt defibrillation, and 448 (22.4%) with delayed defibrillation. Among those surviving to discharge, delayed defibrillation was associated with a lower likelihood of no major disability in neurological status (p=0.01) and functional status (p=0.02).

Conclusion: Delayed defibrillation in the hospital is associated with a worse neurological and functional status among survivors of in-hospital cardiac arrests. Minimizing time to defibrillation represents a major opportunity to improve survival and also neurological and functional status in surviving patients.

The full study was recently published in the *New England Journal of Medicine* 2008;358:9-17 and received much media coverage. From the NEJM article it is seen that there is a graded inverse association between time to defibrillation and survival rate (p for trend <0.001); see figure below. Time will tell how hospitals rise to the challenge of improving time to defibrillation.



Hands-on Defibrillation: An Analysis of Current Flow Through Rescuers in Contact with Patients during Biphasic External Defibrillation (63) Lloyd, M.S. et al. Emory University, Atlanta, GA

Aim: To determine if leakage current is low through a rescuer performing chest compressions at the time of biphasic shock delivery.

Methods: During 18 elective cardioversions using truncated exponential biphasic waveform (median energy 200 joules, range 100-360 joules), an investigator serving as the rescuer placed a hand encased in a polyethylene glove on the patient's anterior chest immediately adjacent to the defibrillating patch with approximately 20 pounds of pressure to simulate chest compressions. Skin electrodes were used to connect the rescuer's thigh to the patient's posterior shoulder, simulating a worst-case return current pathway. During shock delivery, voltage and current through the rescuer were recorded.

Results: In no cases were shocks perceptible to the rescuer. Potential differences in volts (V) between the rescuer's wrist and thigh ranged from 1.7 to 14 V (median 6.7$\pm$2.7 V). Calculated impedances through rescuers ranged from 8190 to 100,400 ohms (mean 33,100$\pm$20,400 ohms). The average leakage current flowing through the rescuer's body for each phase of the shock was 273$\pm$191 microamperes (range 1 to 910 microamperes). All measured values in this series were well below 2500 microamperes, an accepted safety standard for earth-leakage current in medical devices.

Conclusions: Even in a simulated worse case scenario, a rescuer performing chest compressions during biphasic external defibrillation is exposed to low levels of leakage current. This study shows that if gloves are worn it is safe to perform uninterrupted chest compressions during shock delivery, which may enhance the efficacy of defibrillation and cardiocerebral perfusion.

The presenter stated that without gloves, the current is safe but perceptible. Since the principle of "clearing" for a shock has been emphasized for years, it will be interesting to see if the AHA Guidelines change in the future. It will take much unlearning to remove the fear factor of touching the patient during a shock, which is so much a part of our current practice.

Automated External Cardioversion Defibrillation Monitoring in Telemetry Patients (21)
Bakhtiar, A. et al. Atlanta Veterans Affairs Medical Center, Decatur, GA

Aim: To evaluate the safety of automated external cardioverter defibrillator (AECD) monitoring in hospitalized patients. The PowerHeart AECD device attaches by pads to the chest wall and monitors, detects, and within seconds, automatically delivers a 150 joule electric countershock to patients in sustained VF/VT.

Methods: A prospective trial randomized telemetry patients to standard CPR (code team) or standard CPR plus AECD monitoring. Data was collected using the standard Utstein criteria for cardiac arrest.

Results: To date 130 patients have been enrolled into the trial. One patient experienced sustained VT, which was successfully defibrillated 13 seconds after meeting programmed criteria by the AECD. The patient survived the event without neurological complications. No events have occurred in the control arm of the trial. During the same time period, mean time to shock for VT/VF cardiac arrest occurring outside the telemetry ward was 230$\pm$50 seconds. A total of 2311 hours of telemetry data has been analyzed in the AECD arm. The AECD has monitored ambulatory telemetry patients in sinus rhythm, sinus tachycardia, supraventricular tachycardia, atrial flutter or fibrillation, with premature ventricular complexes and non-sustained VT without delivery of inappropriate shocks.

Conclusion: This initial experience suggests that AECD technology is safe, and has the potential to reduce time to defibrillation in cardiac arrest. Additional data is needed to confirm the safety of the AECD technology in other hospital settings than telemetry and to assess its impact on short- and long-term outcomes in patients with in-hospital cardiac arrest. Perhaps this can be one of the new technologies that hospitals can use with high risk patients to decrease the usual time to defibrillation, which often is greater than 2 minutes.

How Rapidly Can People Find an AED? (81) Kaneko, H. et al. Various EMS and medical facilities in Japan

Aim: To investigate how rapidly lay people can find an AED in international airports, and to uncover the factors that facilitate rapid detection of an AED.

Methods: In 20 randomly selected locations in each of two Japanese airports, two people (total of 80) were asked to find an AED as rapidly as possible. The subjects were asked not to run or ask for help. The time needed to find an AED (Ta) and their routes were recorded. The theoretical time (Tt) needed to find an AED was calculated on the diagram assuming that people would reach the nearest AEDs.

Results: When combined over the 2 airports, median Ta was 168 (140-150) seconds and was significantly longer than Tt of 36.4 (17.1-51.8) seconds. Ta was significantly shorter when people reached the nearest AEDs, in 60% of the trials: 147 (62-212) seconds for the nearest AEDs vs. 349 (169-651) seconds for non-nearest AEDs. Whether or not people had advance knowledge about an AED did not affect Ta: 160 (94-387) vs. 177 (94-387) seconds, respectively. Tt was similar for 2 airports, 38.8 (17.1-44.2) vs. 29.8 (14.9-63.5) seconds. Despite the considerable inter-airport difference in the configuration of the on-site AED signs (prominent and protruding with AED pictogram vs. plain and non-protruding without pictogram), Ta was not significantly different between the airports: 163.3 (104.5-342.0) vs. 194.5 (91.5-424.5 seconds).

Conclusion: The theoretical prediction of the time based on the diagram of the facilities significantly underestimates the actual time required to find an AED. Often this was due to the fact that people failed to reach the nearest AED. This suggests that presence of off-site signs showing the direction to the nearest AED is an important factor for rapid detection of an AED. Configurations of the on-site AED signs and the advanced knowledge on an AED appear to be minor factors.

As AEDs are increasingly placed in hospitals to improve the time to defibrillation, it will be important to investigate the issue of how quickly staff can find them in this setting. The configuration/placement of the signs, the consistency of AED location, and staff training should be investigated as they relate to finding the closest AED. The goal in the hospital setting is 1 minute to find the AED, 1 minute to return to the site with the AED, and 1 minute to put the AED on the patient and defibrillate if advised.

Bystander Administered AED Shock Improves Survival from Out of Hospital Cardiac Arrest in US and Canada (1810) ROC Investigators

Aim: To investigate if bystander defibrillation before arrival of EMS personnel improves survival.

Methods: This population-based cohort study analyzed data from 11 US and Canadian urban and rural sites participating in the ROC. Records were reviewed from individuals with non-traumatic OOH cardiac arrest from 12/1/2005 to 11/30/2006 who were evaluated by EMS personnel and received attempted defibrillation before or after EMS arrival or chest compressions by EMS.

Results: Of 9897 EMS-treated OOH cardiac arrests, 2991 (30.4%) received bystander CPR and 249 (2.5%) had an AED placed by bystander. Survival to hospital discharge is shown in the table below.

Overall survival to hospital discharge	7%
Survival with bystander CPR but no AED	8%
Survival with AED applied by bystander	21%
Survival with bystander AED shock delivered	33%
Survival with EMS shock only	15%

The AED was applied by lay volunteers in 32%, by police in 24%, by healthcare workers in 42%, and unknown in 2%. After adjusting for various factors, AED application was significantly associated with survival ($p<0.001$).

Conclusions: Improved survival with AED application by bystanders translates into improved survival in community-based programs. Extrapolating this greater survival from the ROC population base (20 million) to the population of the US and Canada (330 million) suggests that AED application by bystanders currently saves 412 lives per year. Dr. Myron Weisfeldt, lead author of the report, added that the survival rate from bystander administered AED varied by location. Individuals who went into cardiac arrest in airports had the best results, with survival in the 50% range.

The results of this ROC study verify the findings of the earlier Public Access Defibrillation (PAD) trial, which showed that training and equipping lay volunteers to use an AED in community settings doubled the number of survivors after out-of-hospital cardiac arrest compared to training in CPR alone. Note in the ROC study that when lay rescuers provided CPR and attached an AED and the device delivered a shock, survival increased to 33% - more than 4 times that of CPR alone and double the survival rate if only the EMS delivered the shock. The findings provide strong support for making AEDs more widely available in communities. Since the local hospitals are often intimately involved in promotion of AEDs and in their training, it is important that health care practitioners are aware of this study.

What do Descriptive Research Studies Tell about the Nature of Resuscitations?

Ventricular Fibrillation Remains the Primary Presenting Rhythm: Results from the Wearable Cardioverter Defibrillator Human Study (55) Wang, H. et al. Weil Institute of Critical Care Medicine, Rancho Mirage, CA

Aim: To determine if VF remains the leading cause of OOH cardiac arrest.

Methods: The incidence and type of initial arrhythmia for sudden cardiac arrest (SCA) were determined by reviewing stored EKGs for 74 consecutive recipients of wearable cardioverter defibrillators (WCD). Patients with a previously implanted ICD that required change due to infection were the most prevalent recipients of WCDs.

Results: VF/VT was the initial rhythm of SCA in 79.7% of patients and 86.1% of events, while pulseless electrical activity (PEA) occurred in 20.3% of patients and 13.9% of events. 84% of patients survived VF/VT and 18.8% of patients survived PEA.

Conclusion: Over the last two decades clinical studies have shown a progressive decrease in the incidence of VF as the presenting rhythm for OOH cardiac arrest. This study showed that when an EKG is obtained immediately upon cardiac arrest, VF is still the most common arrhythmia.

The Prognostic Factor of Patients with Asystole on Arrival (89) Shokawa, T., Tanigawa, K., & Yamamoto, H. Hiroshima University, Hiroshima, Japan

Aim: To determine the predictors for 24 hour survival in patients presenting with asystole upon arrival to the hospital.

Methods: Consecutive patients with asystole on arrival admitted to Hiroshima University Hospital from April 2002 to January 2007 were retrospectively analyzed. Patients were divided into two groups according to outcomes, i.e. non-survivors vs. survivors at 24 hours after admission, and factors were analyzed.

Results: Of 102 patients with asystole, 14 survived for 24 hours. Univariate analysis found that the factors shown in the table were associated with survival ($p<0.05$).

Variable	Survivors (n=14)	Non Survivors (n=88)	P value
pH	7.12±0.125	6.86±0.23	0.0007
PaO_2 (mmHg)	205.4±166.1	103.5±121.2	0.005
$PaCO_2$ (mmHg)	50.4±28.2	78.0±43.4	0.016
Base excess (mmol/L)	-14.6±7.1	-18.2±11.4	0.0118
Lactate (mmol/L)	15.5±18.5	16.7±6.1	0.0022
Serum potassium (mEq/L)	5.1±1.6	7.7±2.7	0.0001

Multivariate analysis determined that serum potassium concentration independently affected 24 hour survival.

Conclusion: These results suggest that serum potassium level on admission can be used as a strong predictor of survival of patients with asystole. This fact should help providers better determine a care plan and discuss prognosis with family.

Cardiac Arrest in the Emergency Department: A Report from the NRCPR (2018) Kayser, R.G., Ornato, J.P, & Peberdy, M.A. Virginia Commonwealth University, Richmond, VA

Aim: To determine the characteristics of cardiac arrests occurring in the Emergency Department (ED).

Methods: The NRCPR data set of 60,852 adult inpatient cardiac arrest events was used for analysis. Multiple regression analysis compared ED cardiac arrests with those occurring in the ICU, telemetry, or general floors. Subgroup analysis examined traumatic vs. non-traumatic ED cardiac arrests and ED cardiac arrests occurring after a successful pre-hospital resuscitation (recurrent) vs. primary ED cardiac arrest.

Results: ED location significantly predicted improved survival to discharge ($p<0.0001$). The table below shows that patients who had a cardiac arrest in the ED had a better Cerebral Performance Category (CPC) score, a shorter mean post event length of stay (LOS), and were less likely to be declared DNR compared to patients whose arrest occurred in other areas of the hospital.

Outcome Variable	ED	ICU	Telemetry	General Floor	P value
CPC	1.59	1.73	1.96	1.69	$p<0.0001$
Mean post-event LOS	8.6	17.5	16.5	14.2	$p<0.0001$
Declared DNR	23.0%	31.7%	28.8%	31.8%	$p<0.001$

Secondary analysis showed that ED patients with recurrent CA were less likely to survive to discharge (10.1% vs. 24.6%, $p<0.0001$) and were more likely to be declared DNR (27.9% vs. 22.2%, $p<0.0006$) than primary ED cardiac arrests.

Major traumatic injury preceded 6.3% of all ED cardiac arrests. ED trauma cardiac arrest patients had a significantly lower survival to discharge rate than ED patients whose cardiac arrest was not due to trauma (7.5% vs. 23.8%, $p<0.0001$).

Conclusion: ED cardiac arrest patients are a unique population and have better survival and neurologic outcomes compared to patients in other hospital locations. Primary ED cardiac arrest patients have a better chance of survival to discharge than those who re-arrest following a successful pre-hospital resuscitation. The author speculated that outcomes are better because physicians are present in the ED, the patient is found quickly, and the response is rapid.

Incidence and Outcome of OOH Cardiac Arrest in a Large Population-Based Cohort. Observations from the ROC (2229) ROC Investigators

Aim: The incidence and outcome of cardiac arrest are analyzed across regions. The hypothesis was that they were distributed uniformly across regions.

Methods: This was a population-based cohort study. 17,486 cases of non-traumatic cardiac arrest from 12/1/2005 to 11/31/2006 from 10 US and Canadian ROC sites were studied. Cases analyzed were those who were evaluated by organized EMS personnel and received attempts at defibrillation by lay responders or emergency personnel, or chest compressions by EMS personnel; or were pulseless. Select factors were standardized to the North American population after adjusting for age and sex.

Results: Age of the cohort was a mean of 64.7 years; 62.8% were male. See the table below for incidence and outcome of cardiac arrest.

	Incidence/ 100,000	Known Mortality/ 100,000	Known Case Fatality Rate, %	Known Survival to Discharge, %
Non traumatic arrests	94.9	87.2	91.9	3.5
EMS-treated	56.1	48.5	86.5	6.3
VF/VT	12.5	9.2	73.1	15.8

Incidence and outcome of OOH cardiac arrest differed significantly across sites ($p<0.001$ within all groups).

Conclusion: The true incidence and outcome of cardiac arrest in these sites in now known. Additional investigation is necessary to understand and reduce the site variation. The author suggested that the incidence of coronary artery disease could contribute to the variation.

Survival from Out-of-Hospital (OOH) Cardiac Arrest is Better for Children than Adults: The ROC Epistry-Cardiac Arrest (2015) ROC Investigators

Aim: To examine the characteristics of OOH non-traumatic cardiac arrest in patients <20 years of age in the ROC Epistry. It was hypothesized that survival to hospital discharge is less for the pediatric vs. the adult group.

Methods: This was a prospective population-based cohort study with uniform data definitions. 11 US and Canadian urban and rural sites participate in ROC. The pediatric population analyzed were persons <20 years who received CPR by EMTs and/or received a bystander AED shock, or are pulseless but receive no EMS resuscitation, for the time period between 12/2005 through 11/2006. The adult data (n=16,829) was derived from the same registry.

Results: Data from 389 OOH cardiac arrests in children were submitted: See the table below for characteristics of all children with OOH cardiac arrest.

Characteristic	Infants <1 Year N=161	Children 1-11 Years N=104	Adolescents 12-20 Years N=124	All Children N=389
Survival to discharge	6 (3.7%)	11 (10.6%)	12 (10%)	29 (7.5%)
Male	93 (58%)	64 (62%)	89 (72%)	246 (63%)
Bystander CPR attempted	60 (37%)	52 (50%)	37 (30%)	149 (38%)
Non-public location	156 (97%)	86 (83%)	97 (78%)	339 (87%)

315 (81%) patients received EMS treatment. See the table below for characteristics of the EMS-treated OOH cardiac arrest patients.

Characteristic	Infants <1 Year N=133	Children 1-11 Years N=91	Adolescents 12-20 Years N=91	All Children N=315
Survival to discharge	6 (4.5%)	11 (12.1%)	12 (13.2%)	29 (9.2%)
Initial rhythm VF/VT	7 (5%)	3 (3%)	16 (18%)	26 (8%)
Initial rhythm asystole/PEA	87 (65%)	68 (75%)	70 (77%)	225 (71%)
Initial rhythm unknown	39 (30%)	20 (22%)	5 (6%)	64 (20%)
Oral intubation attempted	84 (63%)	66 (73%)	71 (78%)	227 (72%)
EMS scene time, mean minutes	17.3	19.4	26.9	20.7
EMS scene time <10 minutes	31 (32%)	15 (23%)	4 (6%)	50 (22%)
EMS scene time <15 minutes	49 (51%)	25 (38%)	9 (13%)	83 (36%)

Survival of pediatric patients was statistically better than adults for all OOH cardiac arrests (7.5% vs. 3.9%, $p<0.0009$) and for EMS-treated OOH cardiac arrests (9.2% vs. 6.9%, $p=0.001$). EMS scene time was <10 minutes for 22% of children vs. 3.6% of adults, $p<0.001$. Bystander CPR is provided for <40% of all patients.

Conclusion: Survival from OOH cardiac arrest is better among children than adults, and this current survival rate is better than most previous studies. Short scene times are more common in infants and children, suggesting a scoop and run approach for younger patients.

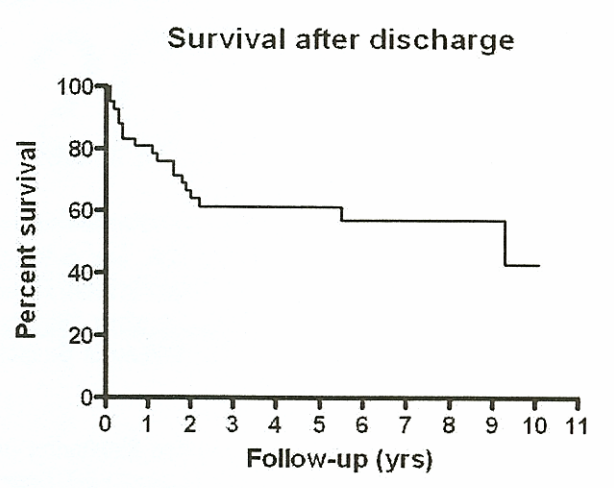
Research Studies of Factors Related to Survival from Cardiopulmonary Arrest

In-hospital Cardiac Arrest: Predictors of Long Term Survival after Being Discharged Alive
(111) Keuper, W. et al. Radboud University Medical Center, Nijmegen, The Netherlands

Aim: To describe the long term survival of patients discharged alive after CPR for an in-hospital cardiac arrest, and predictors for survival.

Methods: This was a retrospective study of patients who suffered an in-hospital cardiac arrest between 1997 and 2004, and survived to discharge. Data were collected using an Utstein format. Survivors were compared with non-survivors and Cox regression analysis was performed to determine predictors of survival.

Results: In this period 222 patients had an in-hospital cardiac arrest and 42 (19%) were discharged alive. Survival in the discharged patients after a median follow-up period of 2.9 years was 57% (n=24).



Predictors of survival were mainly the initial rhythm. Characteristics of non-survivors were:

- Older age (median age 69.3 vs. 56.7 years)
- More frequent diabetes
- More frequent arrhythmias
- More frequent valvular disease
- More frequent cancer in medical history

After adjustment for baseline differences it was found that cancer independently predicted a lower chance of survival.

Conclusion: When a patient is discharged alive after an in-hospital cardiac arrest, the chance of survival is reduced. Only cancer independently predicted a lower chance of survival. Long term survival seems to be determined more by comorbidity than arrest variables.

Left Ventricular Systolic Function and Outcome Following In-hospital Cardiac Arrest (2007) Gonzalez, M.M. et al. Heart Institute, University of Sao Paulo Medical School, Sao Paulo, Brazil

Aim: To evaluate the effect of pre-arrest left ventricular ejection fraction (LVEF) on outcome following cardiac arrest.

Methods: This was a prospective study of all in-hospital cardiac arrests in adults $\geq$18 years at a tertiary cardiac care hospital during a period of 26 months. Among patients with pre-arrest echocardiograms, the outcomes of patients with normal or nearly normal LVEF and those with moderate or severe left ventricular dysfunction were compared.

Results: Of 800 consecutive cardiac arrest patients, 613 (77%) had documented pre-arrest echocardiograms. 19% of patients with normal or nearly normal LV systolic function survived to discharge compared with 8% of patients with moderate or severe dysfunction ($p<0.001$). The two groups did not differ in regard to sustained return of spontaneous circulation (59% vs. 56%, $p=0.47$) or 24-hour survival (39% vs. 36%, $p=0.55$). Among survivors who had post-arrest echocardiograms within 48 hours, LVEF decreased by 27% in those with normal or nearly normal pre-arrest function (60 ± 8% pre-arrest to 44 ± 14% post-arrest, $p<0.001$). LVEF decreased by 28% in those with moderate or severe pre-arrest ventricular dysfunction (32 ± 7% to 23 ± 6%, $p<0.001$). Pre-arrest beta-blocker treatment was associated with higher hospital survival rates (33% vs. 8%, $p<0.001$).

Conclusion: Poor pre-arrest left ventricular systolic function was associated with a lower rate of survival to hospital discharge. Could more aggressive monitoring and treatment of post-arrest myocardial dysfunction improve outcomes?

Spontaneous Body Temperature is Associated with Survival Following In-hospital Cardiac Arrest and Return of Spontaneous Circulation (ROSC): A Report from the NRCPR (58)
Suffoletto, B. et al. University of Pittsburgh, Pittsburgh, PA and several other centers

Aim: To determine the association between body temperature after cardiac arrest and survival to hospital discharge.

Methods: Analysis was performed on data from 14,413 adult subjects with in-hospital cardiac arrest and ROSC who were enrolled in the NRCPR between January 1, 2005 and November 7, 2006. Those who received therapeutic hypothermia were excluded. The lowest (Tmin) and highest (Tmax) body temperature during the first 24 hours after ROSC were included in the analysis.

Results: 5319 (36.9%) subjects survived to hospital discharge. Tmin and Tmax were available for approximately 55% of all patients. See the tables for the odds ratio of survival to discharge by Tmin, Tmax, and Tdelta (change in temperature, i.e. Tmax-Tmin).

Tmin	Odds Ratio (95% confidence intervals)	P value
<32°C	0.16 (0.03-0.93)	0.041
32-34°C	0.60 (0.35-1.06)	0.074
34-36°C	0.97 (0.79-1.19)	0.782
36-38°C	1.00	
>38°C	0.31 (0.16-0.59)	0.000

Tmax	Odds Ratio (95% confidence intervals)	P value
<32°C	0.13 (0.01-1.48)	1.00
34-36°C	0.28 (0.17-0.46)	0.000
36-38°C	1.00	
>38°C	0.62 (0.50-0.76)	0.000

Tdelta	Odds Ratio (95% confidence intervals)	P value
0-1°C	1.00	
1-2°C	0.78 (0.63-0.97)	0.024
2-3°C	0.67 (0.50-0.90)	0.007
3-4°C	0.63 (0.41-0.97)	0.036
4-5°C	0.22 (0.10-0.46)	0.000
>5°C	0.44 (0.17-1.14)	0.092

Conclusions: Spontaneous hyperthermia and hypothermia following in-hospital cardiac arrest is associated with lower odds of survival to discharge. Lability of temperature >1°C is also associated with lower odds of survival to discharge.

Risk of Cardiopulmonary Arrest after Acute Respiratory Compromise (50) Wang, H., Abella, B., & Callaway, C.W. University of Pittsburgh, PA, & University of Pennsylvania, Philadelphia, PA

Aim: To characterize the clinical course of acute respiratory compromise (ARC) patients and their risk of developing cardiopulmonary arrest (CPA).

Methods: This study used ARC data from the NRCPR for patients who required emergency assisted ventilation. For each primary ARC event patient characteristics, clinical presentation, suspected cause and acute interventions were identified. The primary outcome was the development of CPA; secondary outcomes were time to CPA and survival to discharge. Factors associated with developing CPA were also identified.

Results: Of the 4358 ARC events, CPA occurred in 726 (16.7%). Median time from ARC onset to CPA was 7 minutes; CPA occurred within 10 minutes in 65.3% of these cases. Survival to discharge was lower for CPA patients than non-CPA patients: 14.3% vs. 58.4%. Multivariate factors associated with CPA included failed invasive airway, tracheostomy or cricothyroidotomy, pulmonary embolism, hypotension, ECG of bradycardia, paced, or idioventricular, and use of magnesium sulfate. CPA was less likely when patients were conscious or breathing or if sedative induction agents were used.

Conclusion: CPA occurs frequently and rapidly after ARC. CPA following ARC is associated with airway management complications, hypotension, bradycardias and pulmonary embolism. Survival to discharge after ARC-related CPA is low. Medical teams responding to ARC should prepare not only for airway management but also the possibility of CPA. If airway management during ARC was improved, could CPA be reduced?

Research Studies Related to Training and Quality Monitoring of Resuscitation

Resuscitation with Actual Performance Integrated Debriefing Improves CPR Quality and Initial Patient Survival (62) Edelson, D.P. et al. University of Chicago, Chicago, IL and University of Pennsylvania, Philadelphia, PA

Aim: To determine if a debriefing intervention using CPR quality data from actual cardiac arrests (Resuscitation with Actual Performance Integrated Debriefing, or RAPID) would improve CPR performance and initial patient survival.

Methods: All residents and students rotating through the resuscitation team role at a university teaching hospital underwent weekly RAPID sessions between March, 2006 and February, 2007. Facilitators led 30-45 minute debriefing/teaching discussions using actual performance data, obtained from a CPR-sensing defibrillator with audiovisual feedback capability, and highlighted deficiencies in CPR quality and defibrillation. Then these data were compared to an historical control in which a similar defibrillator was used.

Results: CPR quality and outcome data from 123 patients resuscitated during the intervention period were compared to 101 patients in the baseline cohort. CPR quality parameters and defibrillation accuracy were improved compared to the control period. These were associated with a significant improvement in the unadjusted rate of return of spontaneous circulation (ROSC); see table below.

	Baseline	RAPID	P value
Compression depth (mm)	44	50	0.0001
Compression rate (per minute)	100	105	0.003
Ventilation rate (per minute)	18	13	<0.0001
No-flow fraction	0.20	0.13	<0.0001
Pre-shock pause (seconds)	16.0	7.5	<0.0001
Post-shock pause (seconds)	7.1	2.4	<0.0001
Appropriate shocks	110/151 (72.8%)	104/117 (88.9%)	0.001
ROSC	45/101 (44.6%)	73/123 (59.4%)	0.03

After adjusting for shockable vs. non-shockable rhythm, time and location of arrest, and patient demographics, the RAPID intervention was associated with a significant increase in the adjusted odds of ROSC (p=0.03).

Conclusion: Compared to providing feedback alone, the combination of RAPID and real-time audiovisual feedback improved CPR quality, and was associated with an increased rate of ROSC. CPR sensing and recording devices now allow for methods of debriefing that were

previously available only for simulation based education. It appears that the debriefing aids in processing the feedback in order to change performance.

Dr. Lance Becker interviewed Dr. Dana Edelson, the first author on this study, at the AHA Scientific Sessions. This interview can be accessed at:
http://www.heart.org/presenter.jhtml?identifier=3051667

The study from this same group, which showed no statistically significant improvement in ROSC or survival to hospital discharge with *feedback alone* is:

Abella, B.S., Edelson, D.P., et. al. CPR quality improvement during in-hospital cardiac arrest using a real-time audiovisual feedback system. *Resuscitation* 2007;73:54-61.

There are several manual defibrillators available on the market that provide CPR feedback and printed reports of performance: ZOLL R Series, ZOLL M Series, and Philips MRx. This feedback can be used as a basis for debriefing with staff following resuscitations.

Written Evaluation in Advanced Cardiovascular Life Support is not a Predictor for Cardiac Arrest Performance (91) Rodger, D.L. et al. Marshall University, Charleston, WV

Aim: To determine if there is a correlation between the ability of the AHA Advanced Cardiovascular Life Support (ACLS) written cognitive evaluation to predict performance following completion of an ACLS course.

Methods: 34 senior nursing students from 4 nursing schools completed an ACLS course, including the written and practical evaluations. Immediately afterwards, all participants served as team leader for a simulated cardiac arrest event that was video recorded. A panel of expert ACLS instructors who did not participate as instructors in the ACLS course reviewed each video and independently scored team leaders' performances.

Results: There was no significant correlation between written evaluation scores and practical skills performance as rated by the expert instructor panel. Paired samples correlation was .219 (p=.213).

Conclusion: The ACLS performance evaluation works in concert with the ACLS written evaluation to enhance participant competence.