Actionable Patient Safety Solution (APSS) #10:
OPTIMAL RESUSCITATION

Executive Summary Checklist

Reducing preventable deaths requires a multi-disciplinary, multi-specialty collaborative team. In order to implement a program that will optimize resuscitation an implementation plan to complete the following actionable steps should be followed:

- ▢ A multi-disciplinary institutional group, the Resuscitation Outcomes Steering Committee (ROSC), should be designated as primarily responsible for the resuscitation program.
- ▢ A formal mechanism for input data (Afferents) should be identified. This should include both external sources of information, such as guidelines and scientific literature, as well as internal (institutional) data.
- ▢ The institutional ROSC should have input into the Efferent actions in response to Afferent data and perceived institutional resuscitation needs.
- ▢ An effective resuscitation program will engage individual providers and enhance their personal sense of ownership and accountability. Ultimately, this program should become the primary vehicle to reduce preventable deaths and ensure an institutional culture of safety.
- ▢ Outcome data should be presented to the hospital medical executive board monthly.
- ▢ An organized approach to data collection and performance improvement should target various etiologies of cardiopulmonary arrest with regard to reducing arrest incidence, increasing arrest survival and improving end-of-life discussions with patients and families.
- ▢ Institutional resuscitation protocols should consider available evidence, technology, and performance improvement data.
- ▢ Provider training should ensure optimal resuscitation performance and be specific to provider type and clinical unit.
- ▢ Cardiopulmonary arrest resuscitation should emphasize optimal chest compressions and controlled ventilations as recommended by the AHA in their ACLS protocol.
- ▢ Post-resuscitative care should focus on optimizing supportive critical care and consideration of targeted temperature management and early coronary revascularization.
- ▢ End-of-life discussions should provide patients and families with compassionate but realistic expectations regarding goals of therapy and various therapeutic options.
- ▢ Cardiopulmonary arrest prevention should emphasize early recognition of the deteriorating patient by technology that can present an early warning system.
  - Perfusion technologies include sphygmomanometry, ECG, capnometry, clinical assessment (mental status, capillary refill, pulse quality, extremity temperature), pulse oximetry including related perfusion indices, laboratory measures of acidosis (pH, base deficit, lactate, anion gap), and newer modalities (near-infrared spectroscopy, orthogonal polarization, heart-rate variability).
  - Oxygenation technologies include pulse oximetry, blood gas analysis, near-infrared spectroscopy, and clinical assessment.
  - Ventilation technologies include respiratory volumetrics (tidal volume, respiratory rate), blood gas analysis, capnometry, capnography, apnea monitoring, and clinical assessment.

The Performance Gap

The Institute of Medicine 2001 report on quality in healthcare identified failure to rescue as a key opportunity for improving patient safety, decreasing preventable deaths, and reducing healthcare expenditures.[1] The recognition that many in-hospital deaths are preventable has resulted in a myriad of patient safety efforts targeting a variety of clinical scenarios and disease states. While some of these have demonstrated promise, hospitals are often overwhelmed with the selection, implementation, and coordination of these efforts. In addition, healthcare professionals are facing an increasing number of required training modules, but with a concerning lack of engagement in each. The segregation or "siloing" of these efforts limits their clinical effectiveness, effectively devolving them into a regulatory requirement driving so-called "compliance innovation" instead of a truly coordinated effort to improve clinical outcomes.[2]

The ultimate consequence of failure to rescue is unexpected cardiopulmonary arrest.[3] The primary mechanism for maintaining resuscitation competency remains the American Heart Association life support training courses: Advanced Cardiac Life Support (ACLS) and Basic Life Support (BLS).[4] These courses have several limitations, particularly for in-hospital providers:[5,6]

1. ACLS/BLS curricula are heavily based on out-of-hospital cardiac arrest. However, recent evidence documents important differences between out-of-hospital and in-hospital arrest etiologies.

2. ACLS/BLS curricula cannot be modified to address institutional continuous quality improvement (CQI) needs.

3. Treatment algorithms upon which the ACLS/BLS courses are based cannot incorporate the variety of new technologies that offer tremendous potential to improve outcomes. Finally, there is no emphasis on arrest prevention, which is where the most opportunity exists for improving clinical outcomes in the hospital setting.

An institutional resuscitation program should target preventable deaths for a particular hospital or healthcare organization. Thus, each of the core elements described below (Steering Committee, Afferents, and Efferents) should reflect and be adapted to that institution. In addition, the core elements should be linked together in an institutional closed-loop performance improvement system.

---

[1] Institute of Medicine (US). Committee on Quality of Health Care in America. (2001). Crossing the quality chasm: A new health system for the 21st century. National Academy Press.

[2] Blind, K. (2012). The impact of regulation on innovation. NESTA Compendium of Evidence on the Effectiveness of Innovation Policy Intervention.

[3] Schmid, A., Hoffman, L., Happ, M. B., Wolf, G. A., & DeVita, M. (2007). Failure to rescue: A literature review. Journal of Nursing Administration, 37(4), 188-198.

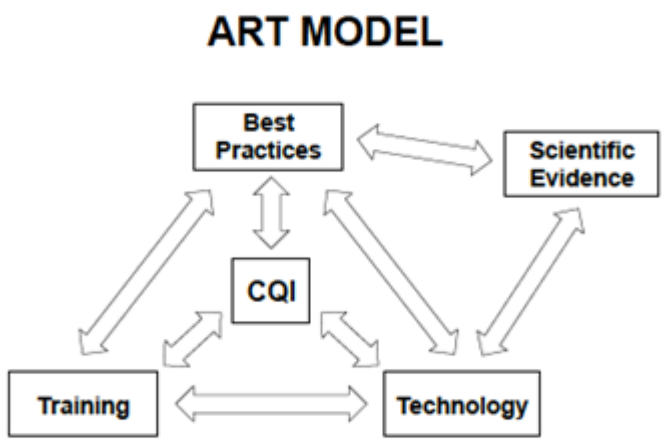
[4] Neumar, R. W., Otto, C. W., Link, M. S., Kronick, S. L., Shuster, M., Callaway, C. W., ... & Passman, R. S. (2010). Part 8: Adult advanced cardiovascular life support 2010 American Heart Association guidelines for cardiopulmonary resuscitation and emergency cardiovascular care. Circulation, 122(18 suppl 3), S729-S767.

[5] Morrison LJ, et al; on behalf of the American Heart Association Emergency Cardiovascular Care Committee, Council on Cardiopulmonary, Critical Care, Perioperative and Resuscitation, Council on Cardiovascular Nursing, Council on Clinical Cardiology, and Council on Peripheral Vascular Disease. Strategies for improving survival after in-hospital cardiac arrest in the United States: 2013 consensus recommendations: a consensus statement from the American Heart Association. Circulation. 2013: published online before print March 11, 2013, 10.1161/CIR.0b013e31828b2770.
http://circ.ahajournals.org/lookup/doi/10.1161/CIR.0b013e31828b2770

[6] Davis, D. (2010). A new resuscitative protocol. Journal of Emergency Medical Services. Retrieved from: http://www.jems.com/articles/print/volume-35/issue-9/patient-care/new-resuscitative-protocol.html

Advanced Resuscitation Training (ART)

Advanced Resuscitation Training (ART) was developed in 2007 at the University of California at San Diego (UCSD) and represents the archetype for an institutional resuscitation program. The ART program represents a comprehensive system of care that targets the reduction of preventable deaths in both the out-of-hospital and in-hospital environments.[6] The ART model links scientific evidence, continuous quality improvement (CQI) data, technology, institutional treatment algorithms, and training (**Figure 1**). Ownership and accountability are transferred to the institution, enhancing both relevance and engagement.



Several critical paradigms lie at the heart of the ART program. The ART Matrix represents a strategy to categorize arrest etiology for each victim. This facilitates a systematic approach to reducing preventable deaths within each category by targeting prevention as well as effective resuscitation. The Matrix also allows for consolidation of multiple hospital-based patient safety initiatives: sepsis, perioperative respiratory depression and sleep apnea, occult hemorrhage, dysrhythmias, deep venous thrombosis/pulmonary embolus detection and treatment, respiratory distress, neurological emergencies, and general critical care. This integration is crucial for effective hospital leadership, outcomes tracking, and training efficiency. The Matrix is based on the ART Integrated Model of Physiology, which identifies three physiological processes – perfusion, oxygenation, ventilation – that define the optimal approach to clinical practice, CQI data collection, technology, and training. Early detection of deterioration is critical for arrest prevention.[7] Most approaches involve a critical tradeoff between sensitivity and specificity, with a measurable incidence of over- or under-utilization of rapid response team resources, limiting overall effectiveness. The ART model employs a stepwise approach to early detection that maximizes both sensitivity and specificity and integrates clinical data, technology, and hospital processes. Each Matrix category is associated with specific static and dynamic risk factors, which in turn suggest particular strategies for vital sign assessment and sensors/technology. Concerning patterns suggesting deterioration trigger a targeted diagnostic and therapeutic approach to both improve specificity and potentially reverse deterioration.

The integrative nature of the ART program is a key component to its effectiveness. In addition to integrating clinical practice, science, technology, CQI, and training, ART also brings together multiple hospital initiatives as discussed above. This allows leadership integration and enhances efficiency. Finally, ART training opportunities provide a conduit to address institutional resuscitation and patient safety needs via regular access to all clinical providers.

The ART program has been successfully implemented at the UCSD as well as the VA Medical Center in San Diego. As a direct result of ART program implementation, arrest incidence has been reduced to 50 percent of baseline values and survival following arrest has doubled and tripled.

---

[7] Nolan, J. P., Soar, J., Zideman, D. A., Biarent, D., Bossaert, L. L., Deakin, C., ... & Böttiger, B. (2010). European resuscitation council guidelines for resuscitation 2010 section 1. Executive summary. Resuscitation, 81(10), 1219-1276.

Leadership Plan

- Resuscitation Outcomes Steering Committee (ROSC): A multi-disciplinary institutional group should be designated as primarily responsible for the resuscitation program. This group should have both ownership and accountability for resuscitation outcomes and should have access to afferent data and
- input into the efferent response. Reporting from the institutional ROSC should be upward to institutional leaders; horizontal to other committees, hospital units, and service lines; and downstream to providers.
- ART program implementation is based on the principles of the Society of Hospital Medicine's Mentored Implementation Program, which has demonstrated effective change management in multiple patient safety initiatives.[8]
    - Hospital administration and clinical leadership must commit to supporting the development and maintenance of an institutional resuscitation program, including support for program leadership as well as commitment to provider training.
        - Of note, the UCSD ART program – including support for MD and RN leaders –reduced life support expenditures by 25 percent.
    - Additional infrastructure support may be provided by patient safety and risk management entities.
- Clinical leadership, particularly for critical care, nursing, and emergency services, must endorse the general principles of the ART program and commit their providers to regular training.
- Financial support should be provided by administration. This may exist as supplemental training, which would require new expenditures.
    - Alternatively, tremendous cost savings may exist with reallocation of existing life support and other training toward an ART program.
- An effective resuscitation program will engage individual providers and enhance their personal sense of ownership and accountability. This can be accomplished by engagement and public support of the institutional ROSC and their activities by hospital leaders, broad representation on the institutional ROSC by various hospital groups, effective modification of training content to address provider-specific needs and issues, and routine feedback of institutional resuscitation data. Ultimately, this program should become the primary vehicle to reduce preventable deaths and ensure an institutional culture of safety.

Practice Plan

- The ART philosophy is of "adaptive" training, which allows provider subgroups – based on provider type (MD, RN, pharmacist, RT) and practice unit – to receive training relevant to their patient population, resources, and role expectations.
- Develop an institutional treatment algorithm and simulation training help reintegrate providers who have received this adaptive training.
- The treatment algorithm is based on institutional capabilities, technology, CQI needs, and clinical leader interpretation of scientific evidence.
- Simulation combines cognitive and psychomotor skills and allows integration and teamwork training, including optimal communication.
- The ART approach to CQI defines specific data elements that identify opportunities for training and algorithm modification. In addition, CQI efforts document clinical outcomes, which are relayed back to providers to enhance ownership and accountability.
- Various aspects of critical care, technical procedures, and surveillance should be recalibrated to utilize ART paradigms and terminology. This affords efficiencies with regard to training and enhances clinical performance and recall during stressful resuscitation events.
- The ART approach to risk factor assessment – both static and dynamic – should be embedded into patient care records and hospital policies and procedures to "institutionalize" the integrated approach to surveillance and monitoring.

---

[8] Society of Hospital Medicine. (2011). Mentored implementation for quality improvement. Retrieved from: https://www.hospitalmedicine.org/Web/Quality_Innovation/SHM_Signature_Programs/Mentored_Implementation/Web/Quality___Innovation/Mentored_Implementation/Landing_Page.aspx?hkey=29e55d16-7fb3-4b82-8e4d-1636ffc44695

Technology Plan

Suggested practices and technologies are limited to those proven to show benefit or are the only known technologies with a particular capability. As other options may exist, please send information on any additional technologies, along with appropriate evidence, to info@patientsafetymovement.org.

- One of the core ART philosophies is the integration of technology into clinical practice, CQI, and training.
- In this regard, the ART program has been highly effective not only in facilitating this integration but also in documenting clinical effectiveness.
- An institutional resuscitation program facilitates modification to clinical algorithms based on available technology as well as training to optimize clinical application. This is critically important in resuscitation, where time is limited to interpret and respond to vital sign and sensor data. This underscores the importance of user interfaces that assist clinical interpretation of data and pattern recognition as well as response to therapy.
- Integration of physiological data with the institutional operational response is also important to assure optimal and timely allocation of clinical resources and prevention of morbidity and mortality. This is another critical element of an ART program.
- The ART Integrated Model of Physiology identifies three physiological processes that provide a framework for clinical practice, training, CQI data collection, and technology:
    - Perfusion
        - Perfusion technologies include sphygmomanometry, ECG, capnometry, clinical assessment (mental status, capillary refill, pulse quality, extremity temperature), pulse oximetry including related perfusion indices, laboratory measures of acidosis (pH, base deficit, lactate, anion gap), and newer modalities (near-infrared spectroscopy, orthogonal polarization, heart-rate variability).
        - Adhesive pulse oximetry sensor connected with pulse oximetry technology proven to accurately measure through motion and low perfusion to avoid false alarms and detect true physiologic events, with added importance in care areas without minimal direct surveillance of patients (in a standalone bedside device or integrated in one of over 100 multi-parameter bedside monitors).[9,10]
    - Oxygenation
        - Oxygenation technologies include pulse oximetry, blood gas analysis, near-infrared spectroscopy, and clinical assessment.
        - Implement noninvasive and continuous hemoglobin monitoring. [11,12] SpHb® adhesive sensors connected to Masimo® Radical-7® with SpHb, or a multi-parameter patient monitor with SpHb, including but not limited to the Dräger® M540/Infinity Acute Care System, Welch Allyn® CVSM, Fukuda Denshi® 8500, Saadat® Aria and Alborz monitors, BMEYE® ccNexfin, and more.
    - Ventilation
        - Ventilation technologies include respiratory volumetrics (tidal volume, respiratory rate), blood gas analysis, capnometry, capnography, apnea monitoring, and clinical assessment.

---

9 Taenzer, A. H., Pyke, J. B., McGrath, S. P., & Blike, G. T. (2010). Impact of pulse oximetry surveillance on rescue events and intensive care unit transfers: A before-and-after concurrence study. The Journal of the American Society of Anesthesiologists, 112(2), 282-287.

10 Shah, N., Ragaswamy, H. B., Govindugari, K., & Estanol, L. (2012). Performance of three new-generation pulse oximeters during motion and low perfusion in volunteers. Journal of Clinical Anesthesia, 24(5), 385-391.

11 Ehrenfeld, J. M., Henneman, J. P., & Sandberg, W. S. (2010, October). Impact of continuous and noninvasive hemoglobin monitoring on intraoperative blood transfusions. In Proceedings of the Annual Meeting of the American Society Anesthesiologists.

12 Awada W.F.N., Maher F. (2013). Reduction in Red Blood Cell Transfusions during Neurosurgery with Noninvasive and Continuous Hemoglobin Monitoring. Proceeding of the Society for Technology in Anesthesia Annual Meeting: p 51.

        - Ability to accurately measure changes in respiratory rate and cessation of breathing with optimal patient tolerance and staff ease of use in order to avoid false alarms, with added importance in care areas without minimal direct surveillance of patients (such as Masimo® rainbow Acoustic Monitoring or sidestream end tidal carbon dioxide monitoring such as Oridion®, Phasein®, or Respironics®).
- Integration of various vital signs and sensor data is facilitated through ART education, which identifies various patterns associated with deterioration from Matrix-specific categories.
    - Remote monitoring with direct clinician alert capability compatible with pulse oximetry technology compatible with recommended pulse oximetry technology (Masimo® Patient SafetyNet™, or comparable multi-parameter monitoring system).
    - Direct clinician alert through dedicated paging systems or hospital notification system.
- Future technologies should focus on the user interface for monitors/sensors to facilitate pattern recognition as well as measuring the therapeutic response in real time.

Metrics

Topic:

Arrest Incidence Rate
Incidence of patients suffering cardiopulmonary arrest (typically expressed per 1000 admissions)

Outcome Measure Formula:

Numerator: Number of patients with an arrest (excluding non-admitted ED patients and arrests occurring in the OR) x 1000
Denominator: Number of admissions over same time period

Metric Recommendations:

Indirect Impact:
All admitted patients

Direct Impact:
All admitted patients

Lives Spared Harm:
$Lives = [(Arrest\ incidence\ rate_{baseline} - Arrest\ incidence\ rate_{measured}) \times Admissions_{measured}]/1000$

Notes:

An arrest is defined as the loss of vital signs requiring either CPR or defibrillation in a patient who is not "Do Not Attempt Resuscitation" at the time of the arrest. An arrest does not require Code Blue team activation. Patients surviving an initial resuscitation attempt but with a later change in code status should be included. Each patient should only be counted once per admission—even if multiple arrest events occur prior to discharge or death.

Data Collection:

Electronic capture from electronic medical record and/or chart review.

Topic:

Arrest Survival Rate
Percentage of patients with an arrest surviving to hospital discharge

Outcome Measure Formula:

Numerator: Number of patients surviving an arrest to hospital discharge (excluding non-admitted ED patients and arrests occurring in the OR) x 100
Denominator: Number patients with an arrest

Topic:

Arrest Related Deaths
Incidence of patients suffering cardiopulmonary arrest who do not survive to discharge (typically expressed per 1000 admissions)

Outcome Measure Formula:

Numerator: Number of patients with an arrest who do not survive to discharge (excluding non-admitted ED patients and arrests occurring in the OR) x 1000
Denominator: Number of admissions over same time period

Metric Recommendations:

Indirect Impact:
All admitted patients

Direct Impact:
All admitted patients

Lives Saved:
$Lives = [(Arrest\ related\ death\ rate_{basline} – Arrest\ related\ death\ rate_{measured}) \times Admissions_{measured}]/1000$

Notes:
An arrest is defined as the loss of vital signs requiring either CPR or defibrillation in a patient who is not “Do Not Attempt Resuscitation” at the time of the arrest. An arrest does not require Code Blue team activation. Patients surviving an initial resuscitation attempt but with a later change in code status should be included. Each patient should only be counted once per admission—even if multiple arrest events occur prior to discharge or death.

Data Collection:

Electronic capture from electronic medical record and/or chart review.

Workgroup

Chair:

Daniel Davis, MD, Arrowhead Regional Medical Center

Members:

Steven J. Barker, PhD, MD, Patient Safety Movement Foundation; Masimo; University of Arizona
Ariana Longley, MPH, Patient Safety Movement Foundation
Ed Salazar, RRT, CPFT, RPSGT, Patient Advocate

Metrics Integrity:

Nathan Barton, Intermountain Healthcare
Robin Betts, RN, Intermountain Healthcare
Jan Orton, RN, MS, Intermountain Healthcare

Revision History

Version	Primary Author(s)	Description of Version	Date Completed
Version 1	Dan Davis	Initial Release	January 2015
Version 2	Dan Davis, Ed Salazar, Ariana Longley, Jim Bialick	Workgroup Review	January 2016
Version 3	Michael Ramsay, Steven Barker, Joe Kiani, Ariana Longley	Executive Review	April 2016
Version 4	Dan Davis, Steven Barker, Ariana Longley, Joe Kiani	Workgroup and Executive Review	January 2017