Executive Summary Checklist

One-third of inpatient deaths may be preventable by improved practice such as better recognition of deteriorating patients and optimal resuscitation strategies.

- A multi-disciplinary institutional group, the Resuscitation Outcomes Steering Committee (ROSC), should be designated as primarily responsible for the resuscitation program.
  - Group members should include physicians, nurses, respiratory therapists, and administrators.
- Identify a formal mechanism for input data (“Afferents”) including 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 output actions (“Efferents”) in response to afferent data and identified institutional resuscitation needs.
- Engage individual providers and enhance their personal sense of ownership and accountability.
- Present efferent data to the hospital medical executive board on a regular basis (monthly/quarterly).
- Target various etiologies of cardiopulmonary arrest with regard to reducing arrest incidence and increasing arrest survival.
- Consider available evidence, technology, and continuous quality improvement (CQI) data when developing resuscitation protocols.
- Provider training should ensure optimal prevention and resuscitation performance and be specific to provider type and clinical unit.
- Emphasize optimal chest compressions and controlled ventilations in the event of cardiopulmonary arrest.
- Post-resuscitative care should focus on optimizing supportive critical care and consideration of targeted temperature management and early coronary revascularization.
- Emphasize early recognition of the deteriorating patient by technology and clinical data that can inform an early warning system.
  - Perfusion technologies include: vital signs, sphygmomanometry, ECG, capnometry, clinical assessment (mental status, capillary refill, pulse quality, extremity temperature), pulse oximetry including related perfusion indices, measures of acidosis (pH, base deficit, lactate, anion gap), and newer modalities (near-infrared spectroscopy, orthogonal polarization, heart-rate variability).
  - Oxygenation technologies include: vital signs, pulse oximetry, blood gas analysis, near-infrared spectroscopy, and clinical assessment.
  - Ventilation technologies include: vital signs, respiratory volumetrics (tidal volume, respiratory rate), blood gas analysis, capnometry, capnography (Masimo, Medtronic (Oridion/Covidien), Nonin, Philips (Respironics) and Welch Allyn), apnea monitoring (Respiratory Motion’s ExSprion), and clinical assessment.
The Performance Gap

The ultimate consequence of failure to rescue is unexpected cardiopulmonary arrest (Schmid et al., 2007). 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) (Neumar et al., 2010). These courses have several limitations, particularly for in-hospital providers (Morrison et al., 2013; Davis, 2010):

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 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 in-hospital setting.

An institutional resuscitation program should target preventable deaths as well as optimal resuscitation performance 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.

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. The ART model links scientific evidence, CQI data, technology, institutional treatment algorithms, and training (Figure 1). Ownership and accountability are transferred to the institution, enhancing both relevance and engagement.

Figure 1: ART Model

Components of the ART Model

Several critical paradigms lie at the heart of the ART program. The ART Matrix represents a strategy to categorize arrest etiology for each at-risk patient. 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 (Nolan et al., 2010). 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 provider types and initiatives, allowing leadership integration and enhancing 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 UCSD as well as multiple pilot sites across the United States. As a direct result of ART program implementation, arrest incidence has been reduced by more than 50 percent and survival following arrest has doubled and tripled.

Leadership Plan

- 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.
- Resuscitation Outcomes Steering Committee (ROSC): A multi-disciplinary institutional group should be designated as primarily responsible for the program. This group should have both ownership and accountability for 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.
  - Of note, the UCSD ART program – including support for MD and RN leaders – reduced life support expenditures by 25 percent.
  - Return on investment has been more than 10-fold, with potential savings in reduced cost-of-care, medicolegal payouts, and improved reimbursement for pay-for-performance/value-based purchasing.
  - 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. Static risk factors include those factors that do not vary throughout the admission (e.g., obesity, advanced age, immunocompromised status, presence of pneumonia). Dynamic risk factors vary as part of a typical hospital course (e.g., medications administered, procedures, sleep/wake status).

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: vital signs, sphygmonanometry, 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) (Taenzer et al., 2010; Shah et al., 2012).
○ Oxygenation
  ■ Oxygenation technologies include: vital signs pulse oximetry, blood gas analysis, near-infrared spectroscopy, and clinical assessment.
  ■ Implement noninvasive and continuous hemoglobin monitoring (Ehrenfeld; WFN). 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: vital signs, respiratory volumetrics (tidal volume, respiratory rate), blood gas analysis, capnometry, capnography (Masimo, Medtronic (Oridion/Covidien), Nonin, Philips (Respironics) and Welch Allyn), apnea monitoring (Respiratory Motion’s ExSpiron), and clinical assessment.
  ■ 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 Related Death
An Arrest Related Death (ARD) is defined as a patient receiving arrest resuscitative efforts (either CPR or defibrillation) at any time during admission who does not survive to hospital discharge.

Outcome Measure Formula:

Numerator: Total number of arrest related deaths
Denominator: Total number of admissions

Rate is typically displayed as ARDs per thousand admissions (ARDs * 1,000/admissions)

Metric Recommendations:

Direct Impact:
Any patient receiving resuscitative efforts

Lives Spared Harm:

$\text{Lives Spared Harm} = (\text{ARD Rate}_{\text{baseline}} - \text{ARD Rate}_{\text{measured}}) \times \text{Admissions}_{\text{measured}}$
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Conflicts of Interest Disclosure

The Patient Safety Movement Foundation partners with as many stakeholders as possible to focus on how to address patient safety challenges. The recommendations in the APSS are developed by workgroups that may include patient safety experts, healthcare technology professionals, hospital leaders, patient advocates, and medical technology industry volunteers. Some of the APSS recommend technologies offered by companies involved in the Patient Safety Movement Foundation that the workgroups have concluded, based on available evidence, are beneficial in addressing the patient safety issues addressed in the APSS. Workgroup members are required to disclose any potential conflicts of interest.

*This Workgroup member has reported a financial interest in an organization that provides a medical product or technology recommended in the Technology Plan for this APSS.
References