AED DEPLOYMENT IN TIERED CARDIAC ARREST RESPONSE

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INTRODUCTION

Resuscitation following cardiac arrest is a critical function within acute care hospitals. Taking advantage of innovations in resuscitation equipment now available, a tiered response to cardiac arrests has been developed and implemented at Toronto's Mount Sinai Hospital. This program blends new technology with modified approaches to Code response. A broader system redesign was prompted by the need to perform an upgrade to existing resuscitation equipment due to technical obsolescence (existing equipment out of support) and clinical obsolescence (shift from monophasic to biphasic waveform). In addition, the system redesign was to shorten time-to-shock intervals, a key factor in survival from sudden death related to arrhythmias.

As part of the technology change, the hospital moved to a three-tiered response, with stand-alone AEDs (automatic external defibrillators) in wall-mounted boxes in non-clinical public areas, AEDs as part of "first responder" carts in non-critical clinical areas (in-patient units, clinics, diagnostic imaging, etc), and manual defibrillators with AED capacity on the ACLS resuscitation carts in critical care areas (Code Team rover cart, ICU, ER, PACU, etc.).

The contributions and expertise of Biomedical Engineering was integral at several levels of involvement, including the development and processing of a request for proposals, human factors testing, equipment selection, acquisition negotiations, upgrade management, and data management, in addition to the basic functions of incoming inspection and preventive maintenance protocol establishment.

BACKGROUND

Mount Sinai Hospital (MSH) is a University of Toronto affiliated 470 bed patient care, teaching and research hospital, with very active Ambulatory Clinics and Emergency Department. Centres of Excellence focus on Women's and Infants Health, Surgical Subspecialties and Oncology, Internal Medicine and Subspecialties, and the Samuel Lunenfeld Research Institute. The Code Team covers approximately 130 actual codes per year, including the MSH site and Princess Margaret Hospital (a separate hospital, part of the University Health Network, but attached physically to MSH).

In Ontario, defibrillation is an act restricted to physicians unless incorporated as part of a formal delegation and certification program. Automated defibrillators simplify the certification process, as complicated tasks such as cardiac rhythm interpretation are no longer required. Thus, mass training of non-physician staff became feasible to ensure that the right equipment was present at the right place with the right staff able to use it. This is in contrast to earlier cardiac system design, wherein sophisticated manual defibrillators were scattered throughout the hospital however use depended on arrival of highly trained critical care staff, leading to considerable delays.

Automatic external defibrillators (AEDs) are defibrillators that analyze cardiac waveforms gained through either ECG electrodes or adhesive defibrillation electrodes, and automatically determine whether the rhythm is "shockable"; i.e. whether it is appropriate to deliver a shock to the patient. While fully automatic defibrillators are available, most units on the market are more accurately called *semi-*automatic external defibrillators, as they require the user to physically press a button to deliver the shock.

The cardiac resuscitation guidelines of the American Heart Association and Canadian Heart and Stroke Foundation clearly state the urgency to resuscitate victims of cardiac arrest with their target to keep response time to less than 3 minutes[1]. Despite the relatively compact physical layout of Mount Sinai Hospital, under mock code trials this target was not achieved for many areas of the hospital.

A key change took place several years ago with the waveforms used in treatment shocks. While some differences remain (maximum energy levels, peak currents and waveform shape), all defibrillator manufacturers have moved to biphasic waveforms, which have been demonstrated to be more effective[2].

The other problem faced by the hospital was the obsolescence of many existing defibrillators. Though defibrillators are typically above average in reliability, it

is a critical device so it is important to use supported equipment.

METHODS

Equipment selection included a detailed usability review. This review was important for this equipment due to the requirement for independent use without error, even with prolonged time between uses or between training and use. The results of the human factors investigation are reported in detail in another paper[3].

Other than usability, other factors that were important in the equipment selection include:

- it must contain a manual override and an ECG display suitable for ACLS trained users
- due to infrequent usage, it should have low maintenance requirements, i.e. no battery charging during stand-by operation and an automatic periodic self-test
- it must be small and portable

When a significant change in technology occurs, as in this change from monophasic to biphasic waveform and the addition of AEDs, it presents an opportune time to adjust a wider range of clinical practice. Several system adjustments were applied; more significant changes are discussed here.

Tiered code response

The hospital felt that the best way to introduce AEDs to the hospital was to redevelop the approach to resuscitation to include a more basic "first responder" cart, a simplified version of the "crash cart" that was previously located in many areas of the hospital, and included a full manual defibrillator and all resuscitation supplies and drugs. For all resuscitations outside of critical care areas (ICU, Emergency Department, Operating Rooms), a fully stocked rover cart was brought from the ICU to the scene, including a manual defibrillator with synchronized cardioversion and pacing capability. Resuscitation equipment already on scene was barely used, and may have distracted first responders from providing critical basic life support measures such as effective chest compressions. Attempts to perform complicated advanced life support maneuvers for patients with maintained pulses without appropriate support staff may also lead to adverse events.

An audit of the old carts also revealed out-dated supplies; this is a problem for areas that seldom use their equipment. Since carts were sealed to ensure all equipment was available when required, regular date checks were not practical. It was deemed more effective to concentrate full resuscitation equipment and supplies in fewer locations, where they tend to be used more frequently. In the low acuity clinical areas, local carts were simplified to focus on first response, to be followed up by more advanced capabilities when required. Each cart included an AED, intubation equipment, suction equipment, a simple drug drawer, basic IV supplies, and personal protective equipment.

Taking advantage of the increasing public awareness and training with AEDs, units were also placed in public areas, to be used by anyone, whether members of the hospital staff or not. These units contribute to safety for staff, patients and visitors in the hospital. Wall cabinets are alarmed to alert staff that resuscitation may be in progress for legitimate usages, but also to prevent theft in other cases.

TIER 1	Wall Cabinets: public areas *AED only, lead 2*
TIER 2	First Responder Carts: inpatient units, clinics, cardiac stress, nuclear medicine, radiology *AED, basic resuscitation equipment and drugs*
TIER 3	ACLS Carts: rover cart and critical care areas (ICU, CCU, ER, OR, PACU) *Manual Defibrillator with AED, full resuscitation equipment and drugs*

No More Paddles

The hospital made a shift from paddles to pads-only on all manual defibrillator carts. There is now only one method of interface between defibrillation devices (AED or manual defibrillator) and the patient. This was accepted well by clinicians, who recognized the advantages of adhesive electrode pads over paddles. Internal paddles were still made available to the Operating Room resuscitation cart in the event of an emergency thoracotomy.

ACLS Guidelines

There were recent changes to the ACLS guidelines[1], so this deployment was a good opportunity to deploy them in MSH through device configuration changes and adjustments to staff education.

Education

In-house staff training was revised in conjunction with the new equipment deployment. Education starts in a self-paced online self-study on the hospital intranet. This is followed up by hand-on training using a high-fidelity patient simulator (Laerdal SimMan) and AED devices with special training battery packs. The

use of intranet-based education material has been successful in gaining greater coverage of staff than organizing a few sessions during regular hours. Also, it is more efficient to have students review material in advance and complete their written exam prior to the hands-on session, thus saving valuable instructor time.

Broader Staff Coverage

All clinical staff will eventually be trained through formal education. Non-clinical staff will have the elective opportunity to complete training to be able to respond to local cardiac arrests. The hospital has taken the position that anyone inside the building who is trained to use an AED may do so in an emergency situation, regardless of official certification status in the hospital. This would be analogous to a public access defibrillation program. Although some initially raised liability concerns, the risk of liability was considered far less to provide automated defibrillation capability as a public safety and occupational health intervention.

RESULTS & DISCUSSION

The revised approach to resuscitation at MSH has resulted in reduced response time for cardiac arrests, as a wider range of staff is qualified to respond to Codes.

In the very first clinical use of a first responder cart, the AED was used in the Heart Failure Clinic to help resuscitate an out-patient who suffered a sudden unexpected cardiac arrest. After successful shock delivery, the patient was very quickly resuscitated, transferred to the CCU, then discharged home in a few days. The cardiologist was understandably pleased with the performance of the AED and the new program proved itself to have a good design.

This was a unique project in that it resulted in both service improvements and cost savings.

Service Improvements

There was a reduced response time for codes due to an increase in the number of defibrillators available, reducing the travel time required by rescuers. Also, there is a vastly increased number of staff capable of providing the critical initial contact and resuscitation attempt.

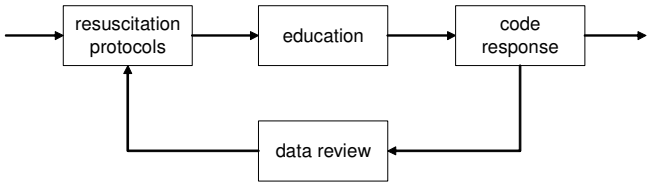
The biphasic waveform, with higher effectiveness at lower energy levels, is also considered superior patient treatment.

Cost Savings

The typical cost for an AED is $2000 to $5000, and even a basic manual defibrillator is $13 000 to $18 000. Even if the total number of AEDs deployed is double the number of defibrillators it replaces, a cost savings of over 50% is realized.

Quality Assurance Capability

With the new technology, a feedback mechanism has been added to the hospital's code response. Depending on the model, the equipment can be configured for automatic collection of audio, waveform and event data. This is collected after each code to a central location and reviewed by critical care physicians to provide feedback and improvements to the code response. For legal and privacy reasons, data is not retained beyond this review.



Other Issues

Standardization of pads was achieved through replacing cables on existing units to match connectors with the new AED devices. The complete standardization of all resuscitation equipment, including manual defibrillators, still requires additional funding.

CONCLUSIONS & FUTURE DIRECTIONS

A successful transition to the tiered cardiac arrest response was made, and the program has proved its value within the first few months of deployment.

A greater amount of integration between resuscitation equipment and hospital information systems, including wireless connectivity, is possible and should eventually be deployed to streamline the review and feedback process. Other technology enhancements, such as CPR feedback provided to clinical staff during resuscitations, will likely be important adjuncts to ensure optimal patient outcome.

ACKNOWLEDGEMENTS

The MSH Acute Resuscitation Committee was responsible for the planning and deployment of the tiered code response.

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