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Research Article

Investment versus Impact- Psychosocial and Metric Analysis of High Fidelity Manikin Use in Hospital-Based Emergency Response Team Training

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Abstract

Background: The American Heart Association (AHA) put forth a set of guidelines for universal standard of care for patients who experience an in-hospital resuscitation event or receive post-cardiac arrest care following an in-hospital or out-of-hospital event. While some studies have suggested that Medical Emergency Response Teams (MERTs) help reduce mortality from unexpected cardiac arrest [1] and reduce the number of unexpected ICU admissions [2], there remains a paucity of data on the impact of formalized training of MERTs on adherence to the recommended AHA guidelines, as well as the impact of quality simulation training in implementing effective MERT training.

Methods: We performed a retrospective cohort analysis of cardiopulmonary and cardiac arrest codes called at ORMC before and after the implementation of the MERT program. We looked at code metrics according to the AHA guidelines one year before the implementation of High Fidelity Mannequin training and one year after its implementation. This data was separated into Group A, pre-MERT training, and Group B, post-MERT training. We analyzed time to chest compressions, time to first dose of epinephrine, and type of rhythm during the actual code, as well as adherence to post resuscitation guideline metrics such as oxygen titration, maintaining normothermia and normal blood pressure.

Results: Statistically significant differences between groups were found in comparing time to delivery of first shock for Ventricular Fibrillation (VF) or Pulseless Ventricular Tachycardia (pVT). No statistical significance was discovered in time to epinephrine, time to first compressions, or post-resuscitation guidelines.

Conclusions: MERT training can assist in better meeting AHA metrics. Use of HFM is a valuable investment for that training in that it can mitigate gaps in assessment, improve clinical outcomes and decreases patient mortality.

Introduction

While acute cardiopulmonary events are not uncommon in a hospital setting, the implementation of a predetermined, systematic approach to them can be. Research on such events emphasizes the need to prioritize patient safety and reduce medical errors to enhance patient outcomes [3,4]. Many institutions have responded to this need by creating Rapid Response Teams (RRTs) or Medical Emergency Teams (METs), comprised of designated individuals who are trained to respond during an emergency. The question of what and how to focus training of individuals to optimize results is imperative to the RRT or MET success. While all training should involve practicing needed skills, but incorporating training in teamwork and communication is a critical component as well. Indeed, studies demonstrate less error and improved patient outcomes when we "train in teams those who are expected to work in teams" [3].

In complement to this, organizations such as the American Heart Association (AHA) and the International Liaison Committee on Resuscitation (ILCOR) -on which the AHA serves as the United States representative put forth guidelines on resuscitation training which serve as a framework and provide a set of universal goals [5,6]. The ILCOR was established to connect resuscitation organizations from around the world, unifying objectives including education on resuscitation, identifying discrepancies and offering clarifications on protocol. In 2014, ILCOR put forth a consensus paper on emergency training, providing templates not just for education, but also to assist in properly monitoring, reporting and conducting research on METs [6,7]. By incorporating the AHA guidelines and ILCOR templates into trainings, high reliability organizations should be able to have clearly defined standards for their teams.

Although integration of these guidelines into training has begun to improve outcomes, creating a setting to train RRTs or METs is difficult; it must contain realistic scenarios, defined objectives, as well as the unpredictability of the patient response. Given this complex amalgamation of necessary elements to training, a central question remains with regards to how to best provide simulation

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training while still adhering to standards. To that end, the literature demonstrates a benefit in the use of High Fidelity Mannequins (HFMs) in simulation training [8-13]. Such mannequins allow not only an improvement in clinical skill performance, but also facilitate training in communication amongst team members, which ultimately improve patient outcome [14-18].

While much of the literature and structure of training has focused on the ILCOR suggestion of higher frequency/lower dose training and template use, there remains a paucity of data collected on the efficacy of HFMs use in congruence with the new guidelines. As such, we are investigating whether HFM use during MET training is a valuable addition to the newly incorporated ILCOR guidelines to achieve AHA target goals in acute cardiopulmonary events. We propose that by incorporating both HFMs and the ILCOR recommendations into MERT training, emergency response teams will adhere to the AHA guidelines, thus improving patient outcomes and decreasing mortality.

Materials and Methods

MERT training

The MERT at ORMC consists of a critical care physician, Physician Assistant (PA) or Nurse Practitioner (NP), Intensive Care Unit Registered Nurse (ICU.RN), Progressive Care Unit Registered Nurse (PCU.RN) and a Respiratory Therapist (RT). Prior to the inclusion of HFMs, formal MERT training included a three-hour review of educational material (TEAM STEPPS, ORMC MERT policy, ACLS algorithms) followed by timed code scenarios. Team STEPPS is acurriculum developed by the Agency for Healthcare Research and Quality (AHRQ) and the Department of Defense (DoD) which is based on the principles of team structure, communication, leadership, situation monitoring and mutual support [19]. The timed code scenarios included ventricular tachycardia, ventricular fibrillation, asystole and pulseless electrical activity.

In August of 2015, a 3G SIM High Fidelity Mannequin (*Copyright Laerdal 167 Myers Corners Road. Wappingers Falls, NY 12590, USA*) was introduced into MERT training initially in two 8-hour sessions, followed by a 4-hour monthly session (Figure 1).

Figure 1: 3G SIM Manikin and ORMC MERT Team.

A 3G SIM High Fidelity Mannequin incorporates the latest computer technology that allows for a very realistic patient presentation. Done wirelessly, the mannequin replicates real-time biomechanics like blood pressure, heart rate and rhythm, respiratory rate, chest rise and fall, and peripheral pulses. The HFM is interactive with monologue capabilities, providing accurate ECG readings, shows appropriate biofeedback in response to intubation, and has areas for peripheral and central intravenous access. It can be programmed to simulate a variety of medical scenarios, including full cardiac or pulmonary arrest, and has isolated responses to management such as seizures, pupillary constriction or dilation, secretions through eyes and mouth. The mannequin is even equipped to provide feedback on CPR performance such as depth and release, compression rate, and hand-off time, allowing it to be a great training tool when simulating an actual scenario in the hospital setting.

The initial training session was attended by approximately 40 staff members, all who had previously served as a member of the RRT prior to the initiation of simulation training. The subsequent monthly trainings were done in smaller groups, attended by those not currently on duty. Over the course of our research, there were no new members added to the MERT, and the total loss of participants was less than five.

The initial training was done using the framework of the Team STEPPS curriculum - a curriculum to which the RRT members had previously been introduced in prior training. We utilized the familiarity of the participants with the Team STEPPS practice to better facilitate the incorporation of a simulation mannikin into the training.

A simulation leader ran through four scenarios - ventricular tachycardia, ventricular fibrillation, a systole, and pulseless electrical activity with a volunteer team using the HFM. Following the simulation, the leader debriefed with the team and the audience wherein clinical skills, timing, and communication were discussed along with suggestions for improvement.

Group selection/metrics

We investigated MERT performance at ORMC between 08/2014 and 08/2015 with respect to national AHA measures [10]. These metrics included:

- Time to chest compressions (<1 minute)
- Time to first shock for a patient in Ventricular Fibrillation (VF) or pulseless ventricular tachycardia (pVT) (≤2 minutes)
- Time to first dose of epinephrine (≤5 minutes)
- Additionally, the AHA post-resuscitation goals were also included. These were:
- Maintenance of normothermia (no temperature ≥38 degrees Celsius for 48 hours)
- Oxygen titration (PaO_2 <300 mmHg within first 24 hours)
- Normotensive blood pressure (Systolic blood pressure maintain >90 mmHg)

Lastly, we determined whether or not the patient survived to discharge. We did not, however, establish the neurological status of the patient at the time of discharge.

We performed a comprehensive chart review, first by identifying all the patients who had a code blue called, and then separating them by time; pre-HFM training (Group A 08/2014-08/2015) and post-HFM training (Group B 08/2015-08/2016). We pulled paper charts, scanned paper charts, as well as any electronic charting done during the code to analyze MERT performance, and viewed all vitals recorded from the time of code through 48-hours after to analyze the post-resuscitation information. The AHA adherence was investigated by comparing mean times of these metrics in our codes to that of the national standard. Chart review reliability and integrity was implemented by adhering to strict categories in data entry and by blinding the data for the purpose of statistical analysis.

To investigate how the HFM training impacted the MERT team performance outside of the AHA guidelines, we tracked 30-day acute care mortality rates, as a percentage, over the two-year period of time. These acute care mortality rates were then averaged over a 6-month time interval for trend analysis. Additionally, we conducted a pre-MERT *vs.* post-MERT survey on hospital staff confidence in the MERT to further examine whether utilizing simulation along with the Team STEPPS approach helped further the perceived communication and teamwork of the group responding.

Hospital staff confidence survey

In order to appreciate the impact of MERT training methods on hospital staff confidence, nurses on the medical units at ORMC were provided with anonymous surveys asking how they felt before and after the initiation of the Medical Emergency Response Team (MERT). This survey not only was used as a gage of hospital confidence in MERTs, but also to better understands overall hospital culture, including elements of interdisciplinary communication. The questions included:

1. Can anyone call an RRT, including patients and families?
2. Do you feel as if you will face push back from your peers if you call an RRT?
3. Do you ever feel "chastised" by the RRT Responders when you call an RRT?
4. Are patients/families instructed on "Code Care" upon arrival to the unit?
5. Do you feel confident about the skill of your Rapid Response Team?
6. Do you encounter any difficulty with reaching physicians prior to calling an RRT?
7. Do your RRT responders treat you with courtesy and respect?
8. Has your experience with calling RRTs improved since the initiation of MERT? *

*Question 8 was only used on the post initiation survey.

IRB ethical committee review process

IRB approval was obtained upon careful ethical review by the ORMC Institutional Review Board on 05/17/2016. Dr. Cleveland Lewis, M.D. was the IRB chair. IRB Number: HH16253.

Statistics

Statistical analysis was performed in a single-blinded fashion. Due to lack of consistent precise time stamps for specific events during a code prior to the implementation of the electronic medical record system, certain code data sets were incomplete and thus the sample size for analyses were ultimately different. This is demonstrated by a different number of codes on Y axis analysis in creating the figures. To account for this missing code data, we decreased the sample sizes in both groups until there was an equal amount of complete data points to establish an equivalent comparison for specific metric analysis and to avoid skewing of the data due to disproportionate inter-group sample sizes. However, sample sizes in each metric analysis was not lowered beyond the point of a minimum n of 12 needed to establish power, as deemed by a power analysis. If there were not enough complete data points to conduct an analysis with the minimum n, the analysis was omitted altogether for lack of statistical power. As such, the number of codes identified and analyzed in each group was different per metric and is reflected in the Y axis of the graphical results.

Normality testing using the Kolmogorov-Smirnov analysis was used to determine if the data was better suited for parametric or non-parametric analysis. Student's T tests as well as Chi-Square (χ^2) tests were used to compare between the pre-MERT implementation and post-MERT implementation groups due to relatively small sample sizes. The Student's T test investigated whether there was a statistically significant difference in average time between the two groups, while the Chi-Square analysis investigated whether MERT training with and without the use of HFMs impacted the ability of the team to meet AHA criterion. Student's T Test data was presented as means ± standard deviations, while χ^2 data was presented as comparative χ values. If patients had multiple codes called within an hour, we excluded the subsequent codes and only used the initial event for analysis. All statistical analyses were performed using Stat Plus statistical analysis program (Analyst Soft, Inc.), and $p<0.05$ was set as the level of significance.

Results

There was a statistically significant difference between Group A and Group B in achieving the AHA standards of delivering first shock for VF or pVT; $\chi^2=9.33$ $p=0.0025$.

Figure 2

This difference showed that Group B had a significantly lower rate of achieving AHA metrics than did Group A. χ^2 analysis showed no other statistically significant difference between Group A and Group B with regards to time of 1st IV/IO epinephrine delivery or time to first chest compressions (Figure 3 $\chi^2=0.411$, $p=0.52$).

(Figure 4 $\chi^2=.00059$, $p=0.98$)

Student's T test analysis showed no statistically significant difference between Group A and Group B in mean time to compressions; $p=0.26$ (Figure 5); mean time 1st shock $p=0.14$ (Figure 6), or time to delivery of 1st IV/I/O epinephrine $p=0.34$ (Figure 7).

χ^2 analysis showed no statistically significant difference between Group A and Group B with regards to achieving AHA post-resuscitation standards of maintaining normothermia or hypotension management $\chi^2=0.39$ $p=0.17$ (Figure 8), $\chi^2=0.70$, $p=0.53$ (Figure 9).

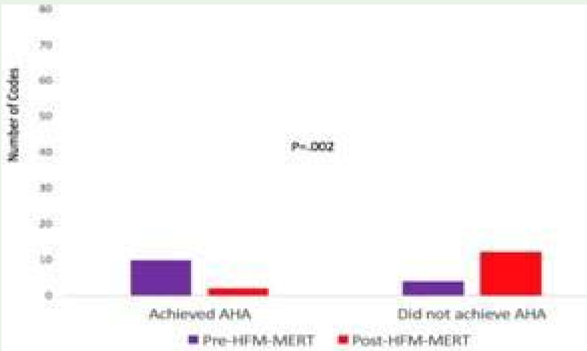

Figure 2: Cardiac & Cardiopulmonary Codes Time to 1st Shock ≤ 2 Minutes.

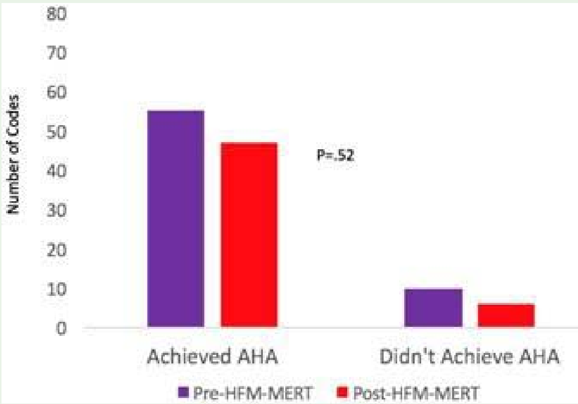

Figure 3: χ2 Analysis of Cardiac & Cardiopulmonary Codes Time to 1st IV/IO epinephrine administered to pulse less adult in ≤ 5 minutes.

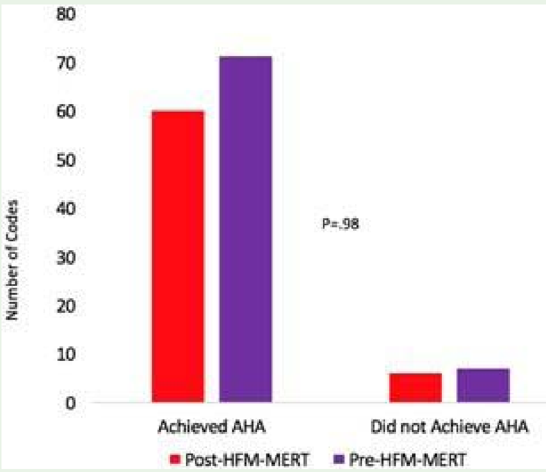

Figure 4: Cardiac & Cardiopulmonary Code Chest Compression Onset <60 Seconds.

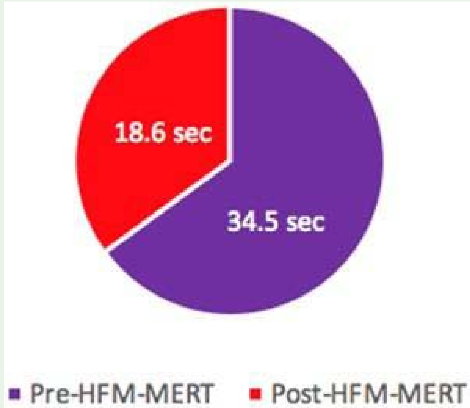

Figure 5: Mean Time to Compressions.

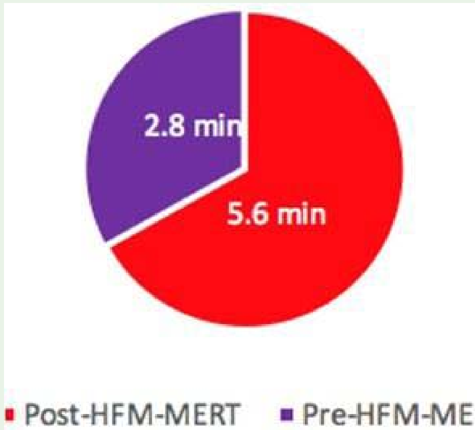

Figure 6: Mean Time to 1st Shock.

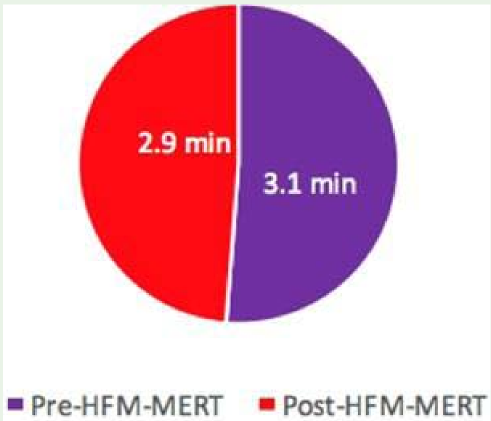

Figure 7: Mean Time to 1st IV/IO Epinephrine Administration.

There was an upward trend of hospital staff confidence in the RRT, as well as willingness to call the team. Confidence in skills and capabilities increased from 89% pre-MERT training to 95% post-MERT training. Before MERT, 23% of the staff felt push back from other staff if they called for the RRT.

After MERT, only 14% felt a push back from other staff if a RRT was called, leading to a demonstrable difference in the number of times the MERT was utilized; in 2014, RRT was called 354 times, in 2015, RRT was called 539 times, while in 2016 RRT was called 626 times (Figure 10).

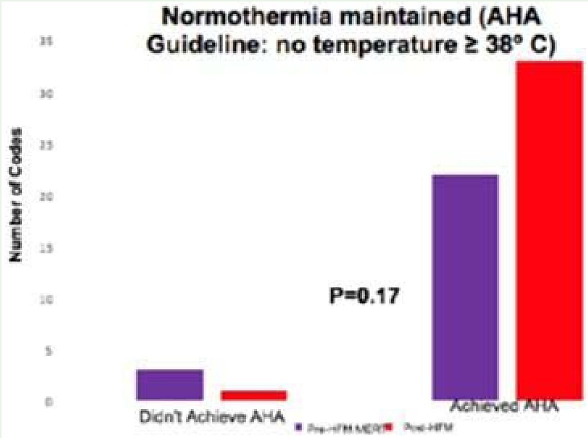

Figure 8: χ2 Analysis of Normothermia maintained.

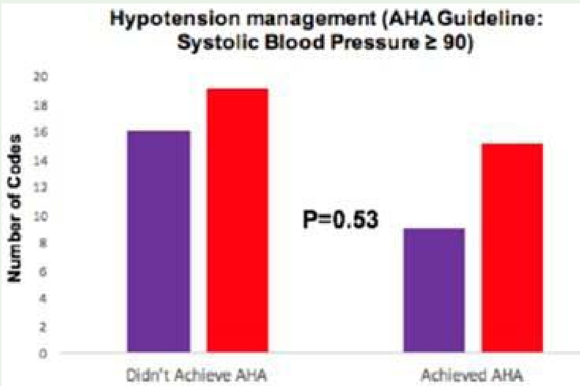

Figure 9: χ2 Analysis of Hypotension Management.

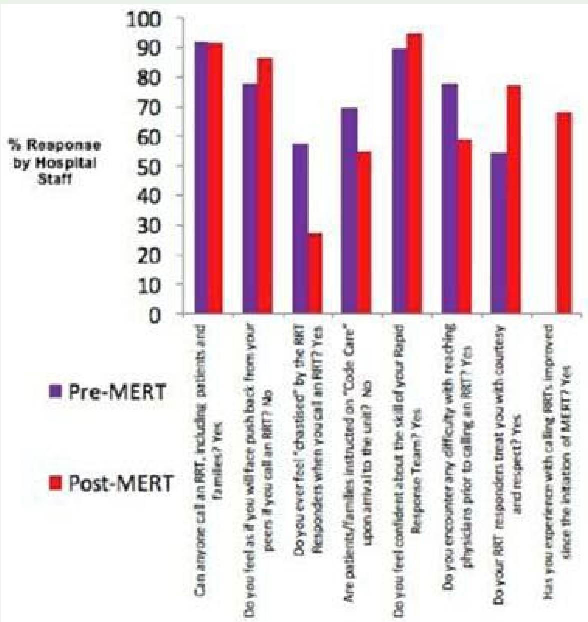

Figure 10: Hospital Staff Survey MERT.

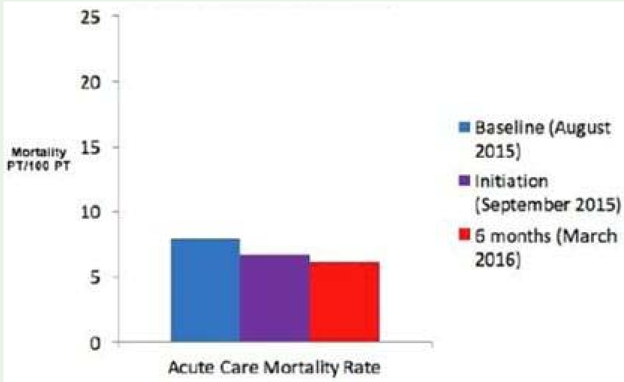

Figure 11: Acute Care Mortality Rate Analysis.

There was a downward trend in average acute care mortality rates between 2015 and 2016. The average acute mortality rate in the pre-MERT training group was 6.54%. The average acute mortality rate in the post-MERT training group was 5.77%. As the number of responses called increased each year, the acute mortality rate decreased (Figure 11).

Discussion

Woven into medical training is the oft-cited see one, do one, teach one. As efforts to increase patient safety and procedural preparedness have expanded in the past 50 years, so too has our scope of what constitutes acceptable and effective training [22]. Simple, low fidelity simulators have been used worldwide for centuries, and provide an immediate alternative to these one, do one, teach one model. More recently, with advancements in technology and development, high fidelity simulation has been utilized to recreate clinical scenarios for the purpose of evaluation or training in the absence of potential patient harm [23]. It can be used to train and/or assess a skill set, to orient to a new procedure, or expose practitioners to uncommon situations. It has been shown to accelerate skill set acquisition and retention, and lowers the rate of extinction [24]. Additionally, in any discussion of simulation, it would be remiss to not discuss the benefits on non-technical skills, such as team working and communication, task management and role assignment, decision making, and leadership [25].

High fidelity simulation allows clinical practitioners to participate in realistic scenarios and receive immediate critique and correction, leading to better patient outcomes during an actual acute medical event. Additionally, training development in response to ever-changing guidelines for resuscitation can be easily facilitated with HFM use. However, this type of simulation does have a cost: at ORMC, one HFM training session cost $ 6,000 for 60 attendees and one mannequin cost upwards of $ 100,000 [26]. HFMs also utilize advanced technology, and training proctors to be familiar with the operating system requires time and effort. Using HFMs in training requires a suspension of disbelief, whereby team members must be willing to participate fully in simulation codes as real, and technical malfunctions can exacerbate this issue and render the training ineffective. As such, the decision to invest in HFM training may be a large one especially for small regional/under developed hospitals.

While HFM training has been beneficial in various realms of clinical medicine [27-30], the decision to incorporate it into MERT training should be based on its impact on post-training outcomes. This pilot study showed that MERT training with HFMs may not necessarily impact the ability to achieve AHA guidelines. Our results revealed that the MERTs trained before and after the incorporation HFMs met AHA guidelines and that there was no statistically significant different between the two groups.

While the nature of research on acute cardiac and/or cardiopulmonary events presents with the unique challenge of precision under high intensity, certain issues in our study and future can present as artifact and even can be confounding factors on data interpretation.

Due to the scale of the AHA metrics, improvements that may otherwise have been studies significant could have distorted measurements. Measuring outcomes on a nominal scale may shroud a true significant difference (i.e. false negative) that would be apparent on an interval scale. For example, a reduction in mean time to first epinephrine pre- and post-HFM training by 30-45 seconds may not manifest as a difference on the current nominal scale, but would prove to be significant on an interval scale.

In addition to difficulties with scale, we found a challenge in documentation. In emergent situations, a dedicated note taker is paramount, not only for accurate medical records, but also for conducting research on quality and improvement. We noted a recurrent issue of documentation in which the start time of the rapid response coincided with start time of chest compressions. As such, the time to compressions from the onset of the code would be noted as 0 seconds, which could arbitrarily lower the average time and thus become an artifact with regards to analysis. During the initial research period, documentation was done by hand. After improvements to the EMR were installed, a dedicated sub-program within the EMR helped keep track of events during a code with time stamps. This led to increased accuracy in tracking AHA criterion adherence. As such, there was a discrepancy in data acquisition and thus the assessment of statistical significance between the two groups.

Despite the afore mentioned challenges, our group did find a significant difference on χ^2 analysis regarding the delivery of a shock to patients in VF or pVT in under two minutes, demonstrating a lower proportion of codes could reach AHA guidelines after the use of HFM in MERT training as compared to those before. Yet, there was no statistically significant difference in the average times between the two groups when analyzed on a Student's T Test. This duplicity highlights the importance of group size as well as scale in statistical analysis. Be that as it may, a decrease in performance, if reproducible at a larger scale, may elucidate fundamental issues in the use of HFMs in MERT training such as suspension of disbelief, lack of translatability to areal scenario or perhaps a problem with the protocol utilized within the training session.

An important element not always included in the discussion of HFM training is its effect on the non-technical skills, such as team working and communication, task management and role assignment, decision making, and leadership [25]. In post-training surveys conducted at ORMC, those participating - including nurses, physicians, and respiratory therapists - cited an increased knowledge in skills expected of them during a code, a greater comfort with the proscribed algorithms used, clearer understanding of their role in a code situation, and improved communication amongst team members. The positive impact of HFM training was also demonstrated in the other non-participating hospital staff. Prior to the initiation of formal MERT training, the staff filled out a survey ranging from comfort in calling an RRT to confidence in the skills of MERT.

We found that in almost every category asked, there was positive impact of MERT training for the rest of the hospital staff. If the use of HFM simulation in MERT training can translate into a more confident team as well as an equal or improved performance, the confidence of other hospital employees in the MERT's ability and utility could increase. Confidence in the MERT skill level rose almost 10%, interpersonal difficulties dropped almost 20%, and fear of chastisement in calling an RRT dropped 30%. The positive psychological impact on hospital confidence in the MERT is a fundamental contribution of training which is often undervalued. Uncertainty felt by staff or hesitation in calling a rapid response negates any positive benefits of training teams to achieve AHA guidelines; such metrics cannot be attained if codes are not called.

We hypothesized that HFM use would significantly improve current MERT training for acute cardiopulmonary events. While this investigation showed few differences with the use of HFMs, it reaffirmed the strong quality of current MERT training. Beyond the AHA metrics, MERT training improved communication amongst team members and strengthened the confidence of hospital personnel to utilize the MERT. Further, when mirrored with decreased hospital acute care mortality rates, it is clear that MERT training serves utility in improving quality of care.

Looking forward, we plan to continue this research with a prospective controlled study, with an emphasis on post-code care simulation scenarios. This will include an analysis on postcode AHA metrics such as normothermia maintained below 38°C, hypotension management with a systolic blood pressure ≥90, survival to discharge and functional status at discharge [10]. Additionally, we plan to change the training protocol to involve smaller groups during simulations, and take into consideration specific limitations presented in this study to more strictly compare groups. We believe the current pilot study as well as our planned directions will have a high impact on the use and implementation of HFMs into improving MERT training given the specificity with which we are examining outcomes. While more investigation is needed with a larger sample size and clearer data delineation, the use of HFMs may prove to show no significant clinical improvement to current training protocols, especially if those protocols already train teams that respond correctly, cohesively, and swiftly.

References

1. Buist M, Moore G, Bernard S, Waxman B, Anderson J, Nguyen T. Effects of a medical emergency team on reduction in incidence of and mortality from unexpected cardiac arrest in hospital: preliminary study. BMJ. 2002; 324: 387-390.

2. Bristow P, Hillman KM, Chey T, Daffurn K, Jacques TC, Norman SL, et al. Rates of in-hospital arrests, deaths and intensive care admissions: the effect of a medical emergency team. Med J Aust. 2000; 173: 236-240.

3. Kohn L, Corrigan J, Donaldson M. To Err is Human: Building a Safer Health System: Institute of Medicine (US) Committee on Quality of Health Care in America. National Academies Press (US). 2000.

4. Reader T, Flin R, Cuthbertson B. Communication skills and error in the intensive care unit. Curr Opin Crit Care. 2007; 13: 732-736.

5. Yancy C, Jessup M, Bozkurt B, Butler J, Casey D, Drazner M, et al. 2013 ACCF/AHA Guideline for the Management of Heart Failure. A Report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines. Circulation 2013.

6. Peberdy M, Cretikos M, Abella B, Devita M, Goldhill D, Kloeck W, et al. ILCOR Consensus Statement. Recommended Guidelines for Monitoring, Reporting, and Conducting Research on Medical Emergency Team, Outreach, and Rapid Response Systems: An Utstein-Style Scientific Statement. Circulation. 2007; 166: 2481-2500.

7. Perkins G, Jacobs I, Nadkarni V, Berg R, Bhanji F, Biarent D, et al. ILCOR Consensus Statement. Cardiac Arrest and Cardiopulmonary Resuscitation Outcome Reports: Update of the Utstein Resuscitation Registry Templates for Out-of-Hospital Cardiac Arrest. Circulation. 2015; 132: 1286-1300.

8. Frengley R, Weller JM, Torrie J, Dzendrowskyi P, Yee B, Paul AM, et al. The effect of a simulation-based training intervention on the performance of established critical care unit teams. Crit Care Med. 2011; 39: 2605-2611.

9. Dwyer T, Searl K, McAllister M, Guerin M, Friel D. Advanced life simulation: High-fidelity simulation without the high technology. Nurse Educ Pract. 2015; 15: 430-436.

10. McGaghie W, Issenberg S, Cohen E, Barsuk J, Wayne D. Does simulation-based medical education with deliberate practice yield better results than traditional clinical education? A meta-analytic comparative review of the evidence. Acad Med. 2011; 86: 706-711.

11. Baker D, Day R, Salas E. Teamwork as an Essential Component of High-Reliability Organizations. Health Health Serv Res. 2006; 41: 1576-1598.

12. DeVita M, Schaefer J, Lutz J, Wang H, Dongilli T. Improving medical emergency team (MET) performance using a novel curriculum and a computerized human patient simulator. Qual Saf Health Care. 2005; 14: 326-331.

13. Lineberry M, Walwanis M, Reni J. Comparative Research on Training Simulators in Emergency Medicine A Methodological Review. Simul Healthc. 2013; 8: 253-261.

14. Cheng A, Lockey A, Bhanji F, Lin Y, Hunt E, Lang E. The use of high-fidelity manikins for advanced life support training-A systematic review and meta-analysis. Resuscitation. 2015; 93: 142-149.

15. Campos JH. High fidelity manikins for airway training: can it be successfully translated into clinical practice? Minerva Anestesiol. 2014; 8: 1-2.

16. Maxwell W, Mohorn P, Haney J, Phillips C, Lu Z, Clark K, et al. Impact of an Advanced Cardiac Life Support Simulation Laboratory Experience on Pharmacy Student Confidence and Knowledge. Am J Pharm Educ. 2016; 80: 140.

17. Thielen M, Joshi R, Delbressine F, Oetomo S, Feijs L. An innovative design for cardiopulmonary resuscitation manikins based on a human-like thorax and embedded flow sensors. Proc Inst Mech Eng H. 2017; 231: 243-249.

18. Sword D, Thomas K, Wise H, Brown D. A Novel and Cost-Effective Method for Evaluating Cardiopulmonary Auscultation Skills in Student Physical Therapists. J Allied Health. 2017; 46: e9-e13.

19. Pocket Guide: Team STEPPS. 01/14.

20. Bernard S, Gray T, Buist M, Jones B, Silvester W, Gutteridge G, et al. Treatment of Comatose Survivors of Out-Of-Hospital Cardiac Arrest with Induced Hypothermia. N Engl J Med. 2002; 346: 557-563.

21. Holzer M. Mild Therapeutic Hypothermia to Improve the Neurologic Outcome After Cardiac Arrest. N Engl J Med. 2002; 346: 549-556.

22. Perkins GD. Simulation in resuscitation training. Resuscitation. 2007; 73: 202-211.

23. Green M, Tariq R, Green P. Improving Patient Safety through Simulation Training in Anesthesiology: Where Are We? Anesthesiol Res Pract. 2016; 2016.

24. Murray DJ. Current trends in simulation training in anesthesia: a review: Minerva Anestesiol. 2011; 77: 528-533.

25. B Yee, Naik VN, Joo HS, Savoldeli GL, Chung GY, Houstan PL, et al. Nontechnical skills in anesthesia crisis management with repeated exposure to simulation-based education: Anesthesiology. 2005; 103: 241-248.

26. SimMan 3G.

27. Frengley R, Weller JM, Torrie J, Dzendrowskyj P, Yee B, Paul AM, et al. The effect of a simulation-based training intervention on the performance of established critical care unit teams. Crit Care Med. 2011; 39: 2605-2611.

28. Kenward G, Castle N, Hodgetts T, Shaikh L. Evaluation of a Medical Emergency Team one year after implementation. Resuscitation. 2004; 61: 257-263.

29. Pettineo C, Vozenilek J, Wang E, Flaherty J, Kharasch M, Aitchison P. Simulated Emergency Department Procedures with Minimal Monetary Investment Cricothyrotomy Simulator. Simul Healthc. 2009; 4: 60-64.

30. Nolan J, Hazinski MF, Aickin R, Bhanji F, Billi JE, Callaway CW, et al. Part 1: Executive summary 2015 International Consensus onCardiopulmonary Resuscitation and Emergency Cardiovascular Care Science withTreatment Recommendations. Resuscitation. 2015; 95: e1-31.