Optimizing Mastery Learning Environments: A New Approach to Deliberate Practice for Simulation-based Learning

Julie Rice, MD, Rodney Omron, MD, and Hugh Calkins, MD

ABSTRACT

Background: Deliberate practice (DP) is a method of mastery learning widely used in healthcare education. Investigations into improved mastery learning environments are important as we move to competency-based educational models. The objective of this pilot project is to create and test the feasibility of a simulation-based learning methodology based on close adherence to the tenants of DP for the acquisition of mastery knowledge.

Methods: We created a new methodology for simulation-based mastery learning modules after review of the tenants of DP. A module was constructed to highlight important aspects of supraventricular tachycardia (SVT) management in accordance with current American Heart Association practice guidelines and underwent expert review. Ten emergency medicine interns completed the module as part of the pilot. The number of case attempts, critical actions completed, and time to cardioversion of unstable patients were recorded. Resident confidence was reported before and several months after the module via survey instrument.

Results: Six cases of patients presenting with SVT were created and critical actions were defined. Cases were ordered in increasing difficulty to form a module in which learners were placed immediately into more complex contexts to practice the skill of SVT management with feedback provided between each case attempt. Residents averaged 2.5 attempts to complete case one. All completed case six on first attempt. All residents completed the six cases within the 2-hour module. Time to cardioversion decreased significantly on repetitive practice. Increased resident confidence in several areas of SVT management was maintained several months postintervention.

Conclusion: The best methods for the use of DP to encourage mastery learning have not been well defined. Participation in our pilot case increased novice trainee performance and confidence in the management of SVT. Several challenges inherent in testing mastery knowledge acquisition were encountered and will inform future study of this new educational strategy.

Deliberate practice (DP) is a method of mastery learning that improves learner performance in procedural skills,^{1,2} resuscitation performance,³ and teamwork dynamics⁴ in simulated scenarios, making it a valued component of emergency medicine education. Dr. William McGaghie, a leader in mastery education, challenged educators to stop reporting data that DP is superior to traditional methods of simulation-based

From the Department of Emergency Medicine (JR, RO) and the Department of Arrhythmia Services (HC), Johns Hopkins Medical Institutions, Baltimore, MD.

Received November 14, 2017; revision received January 9, 2018; accepted January 10, 2018.

Presented at the Mediterranean Emergency Medicine Congress, Lisbon, Portugal, September 2017.

Author Contributions: JR developed, designed, and implemented the educational concept; acquired the educational data; interpreted data; drafted the initial manuscript; and incorporated co-author comments into the final manuscript draft. She is a practicing emergency medicine physician and reviewed relevant literature for case development. RO reviewed educational case content as a practicing emergency medicine physician. He also analyzed data, provided statistical support, and assisted in the manuscript drafting. He is a practicing emergency physician and also reviewed the cases for best practices in emergency medicine. HC is an author of the American Heart Association Guidelines on Tachyarrhythmias as a cardiology content expert and reviewed all cases for accuracy. He also assisted in drafting the final manuscript.

The authors have no relevant financial information or potential conflicts to disclose.

Supervising Editor: Teresa Chan, MD, MHPE, FRCPC.

Address for correspondence and reprints: Julie Rice, MD; e-mail: Jrice24@jhmi.edu

AEM EDUCATION AND TRAINING 2018;2:77–81

education and to start investigating how to best engineer mastery learning environments.⁵

In response to this challenge, we reviewed the tenants of DP to see if improvements could be made in its application to simulation-based education. Ericsson⁶ described DP as having a well-defined goal, a motivated learner, feedback during practice, and many opportunities for repetition. He also adds that after a learner masters a brief task, the task should be placed in more complex contexts to fully integrate the skill into the learner's repertoire. Educators often employ DP in simulated scenarios, observing a learner as they repeat a skill or procedure multiple times and giving feedback between each attempt to improve performance. However, this approach fails to place the learner in more complex contexts to test and master their skill until they encounter the skill again in the clinical area.

We hypothesize that changing common simulation educational methodology to emphasize the practice of new skills in more complex contexts will better adhere to the tenants of DP and result in more effective mastery learning. We began this investigation by creating a learning module to test the methodology's feasibility and observed learner performance as they navigated the activity. The module is intended to teach supraventricular tachycardia (SVT) management in accordance with American Heart Association (AHA) guidelines. In this feasibility study, we chose to measure knowledge acquisition by measuring time to cardioversion for unstable arrhythmias. Resident confidence in several areas related to SVT management was measured both before and several months after the intervention to determine if gains made during the module would be retained.

METHODS

Institutional Review Board Review

This study was reviewed and approved as an exempt study by the Johns Hopkins Medicine Institutional Review Board.

Development of Simulation-based Enhanced DP Learning Module

Best practices in DP as defined by Ericsson⁶ were reviewed by study authors. Relevant emergency medicine texts and the 2015 AHA Guidelines on SVT management were reviewed for best practices in the emergency department (ED) setting.^{7,8} Six simulation

cases were created to highlight important aspects of SVT management in a variety of different patient populations and ordered in increasing difficulty to make a 2-hour simulation module (Table 1). A critical action checklist was developed for each case. The cases underwent expert review by emergency medicine and cardiology faculty, including one of the 2015 AHA Supraventricular Tachycardia Guideline authors. Revisions were made based on reviewer suggestions.

Module Implementation

Simulations were performed during the last half of PGY-1, January through June, using a life size patient simulator (Laerdal SimMan) and Zoll R-series defibrillator (Model 3052003101110013). Modules were taught with 1:1 faculty to learner ratio and data collected on participants by faculty instructor. Learners began the module with Case 1 and received feedback after each attempt. Each case was repeated until all critical actions were met. After completion of each case, the learner advanced to the next case, which increased in difficulty and complexity. The module ended when the learner demonstrated case mastery via critical action checklist completion in all six cases.

Data was collected on number of critical actions met for each case attempt and total number of case attempts. Time to synchronized cardioversion for unstable patients was recorded using Simulator software (Laerdal Instructor application software). Confidence in several areas of SVT knowledge and management were measured via pre- and postintervention surveys. General learner feedback on format was also requested via anonymous survey instrument.

RESULTS

Brief descriptions of the six created cases along with critical actions can be found in Table 1. Ten emergency medicine interns completed the module as part of the pilot. For the first case, participants averaged 2.5 attempts before all critical actions were met (range = 1–4). All 10 participants successfully completed all critical actions on cases 4, 5, and 6 on first attempt.

Time to synchronized cardioversion for patients in unstable SVT in cases 2, 5, and 6 also improved with a mean ($\pm$ SD) of 176 ($\pm$ 45) seconds for case 2, 97 ($\pm$ 35) seconds for case 5, and 63 ($\pm$ 15) seconds for case 6. The differences seen between cases 2 to cases

Table 1
Summary SVT Simulation Module Case Series and Critical Actions

Case	Case Title	Case Description	Critical Actions
1	Stable SVT	Patient with AVnRT. Converts to NSR after adenosine. No complications.	<ul style="list-style-type: none"> • Place two large-bore IV lines • Place patient on cardiac monitor, SpO₂ monitor, BP taken • Place AED pads on patient • Obtain 12 lead ECG and recognize SVT • Attempt vagal maneuver • Appropriate use and dose of adenosine • Run rhythm strip during adenosine administration • Reassess patient after rhythm conversion
2	Unstable SVT	Patient with AVnRT presenting with hypotension. Rhythm conversion after cardioversion with 100 J. No complications.	<ul style="list-style-type: none"> • Place two large-bore IV lines • Place patient on cardiac monitor, SpO₂ monitor, BP taken • Place AED pads on patient • Recognize SVT on 12-lead ECG • Identify unstable patient and perform synchronized cardioversion at AHA recommended dose • Appropriate use of sedation or pain control • Reassess patient after rhythm conversion, including complete vital signs and repeat ECG • Admit patient to appropriate level of care
3	Refractory SVT in a patient with significant comorbidities	Patient with history of CHF presenting with AVnRT refractory to adenosine. No evidence of volume overload on examination. Rhythm converts with electric cardioversion or rate control per AHA guidelines.	<ul style="list-style-type: none"> • Place two large-bore IV lines • Place patient on cardiac monitor, SpO₂ monitor, BP taken • Place AED pads on patient • Perform cardiorespiratory examination to assess for volume overload with history of CHF • Attempt vagal maneuvers • Appropriate use and dose of adenosine; rhythm strip during adenosine administration • Troubleshoot adenosine administration • Appropriate treatment of refractory SVT with rate control or synchronized cardioversion • Cardiology consultation for patient with refractory, symptomatic SVT with significant comorbidities
4	The stable pregnant patient with SVT and WPW	Stable, pregnant patient with AVRT. Postconversion ECG with preexcitation suggestive of WPW.	<ul style="list-style-type: none"> • Place two large-bore IV lines • Place patient on cardiac monitor, SpO₂ monitor, BP taken • Place AED pads on patient • Assess history including pregnancy status • Attempt vagal maneuver • Appropriate use and dose of adenosine and run rhythm strip during adenosine administration • Recognition of WPW on post conversion ECG • Consult cardiology for pregnant patient with WPW
5	The unstable pregnant patient with WPW and antidromic tachyarrhythmia	Same patient as case 4 returns with antidromic tachyarrhythmia and hypotension. Requires immediate cardioversion.	<ul style="list-style-type: none"> • Place two large-bore IV lines • Place patient on cardiac monitor, SpO₂ monitor, BP taken • Place AED pads on patient • Immediate synchronized cardioversion of pregnant patient with unstable antidromic AVRT • Cardiology and obstetrics consultation • Admit patient who experienced unstable rhythm to appropriate level of care
6	The unexpected decompensation while treating SVT in a patient with WPW	Same patient as case 4 and 5 returns with stable AVRT. Despite learner actions, midcase decompensation to rapid atrial fibrillation down accessory pathway that requires cardioversion within 90 seconds to prevent cardiac arrest.	<ul style="list-style-type: none"> • Place two large-bore IVs • Place patient on cardiac monitor, SpO₂ monitor, BP taken • Place AED pads on patient • Recognition of patient decompensation during treatment of SVT in WPW patient • Synchronized cardioversion of rapid atrial fibrillation • Admit patient who experienced unstable rhythm to appropriate level of care

AED = automated external defibrillator; AHA = American Heart Association; AVnRT = atrioventricular nodal reentrant tachycardia; AVRT = atrioventricular reentrant tachycardia; BP = blood pressure; CHF = congestive heart failure; ECG = electrocardiogram; IV = intravenous; NSR = normal sinus rhythm; SpO₂ = oxygen saturation; SVT = supraventricular tachycardia; WPW = Wolff-Parkinson-White.

5 and 6 were statistically significant ($p < 0.0001$ and $p = 0.0004$).

A mean of 3.5 months after the educational intervention (range = 2–6 months) all participants reported significant increased confidence compared to

preintervention confidence with regard to SVT fund of knowledge, management approach, ability to foresee and manage complications that arise during SVT management, and ability to manage SVT despite significant comorbidities (Table 2).

Table 2
Mean Confidence Reporting for SVT Management by Intern Participants

Category	Pretest Confidence (Likert 1–5)	Posttest Confidence* (Likert 1–5)	p-value
How confident did you feel about your fund of knowledge regarding SVT (AVRT or AVnRT) while caring for those patients?	2.3	3.6	<0.005
How confident did you feel about your management approach while caring for patients with SVT (AVRT or AVnRT)?	2.4	3.8	<0.005
How confident did you feel about your ability to foresee and manage complications which may have arisen during your care of patients with SVT (AVRT or AVnRT)?	1.6	3.1	<0.005
How confident are you in your ability to manage SVT (AVRT or AVnRT) in patients with significant comorbidities (i.e., CHF, volume overload, Wolff-Parkinson-White)?	1.7	3.0	<0.005

AVnRT = atrioventricular nodal reentrant tachycardia; AVRT = atrioventricular reentrant tachycardia; CHF = congestive heart failure; SVT = supraventricular tachycardia; WPW = Wolf Parkinson White.

*Posttest confidence mean 3.5 months from educational intervention.

DISCUSSION

Despite all having previously completed advanced cardiac life support (ACLS) training, intern participants still required a mean of 2.5 attempts to complete the most basic scenario and rated their initial confidence in SVT management as low. However, by the end of the module, all were able to complete the most complicated case on the first attempt. We believe that the repetition of concepts allows for pattern recognition in different scenarios, thus reducing cognitive load so learners can better manage complicated patients and presentations. The improvement in time to cardioversion of unstable patients, despite very different clinical scenarios, supports the idea that learners were able to better recognize unstable SVT and demonstrate more decisive management of unstable rhythms.

Resident confidence improved significantly across all measured domains and was maintained several months after the intervention. Although confidence and competence are often poorly correlated, we believe that confidence in management of unstable disease is an important component in learning to lead critical care teams in the ED.

In survey responses, residents embraced the new format. One surveyed resident responded that the different cases helped them form “a mental map to apply the (ACLS) algorithm.” Based on this positive feedback and gains in resident performance and confidence, our simulation team plans to continue studying the educational impact of this format.

LIMITATIONS

There are several limitations to this pilot study, the most important of which is the inability to demonstrate mastery knowledge acquisition. Skills in advanced clinical decision making are difficult to assess as there are no standard metrics for mastery.⁹ We found no single posttest simulation scenario adequate to assess mastery knowledge acquisition in SVT management and are unsure if simulated testing is feasible for this purpose. We were also unable to use clinical outcomes to demonstrate mastery. This was due to the infrequency that patients with acute tachyarrhythmia present to our ED and the difficulty determining what a resident’s clinical management decisions would be independent of faculty supervision. Further testing of this educational methodology will include a change in educational topic to a skill observed more frequently in the clinical area so that resident clinical decision making could be better measured by expert raters or clinical data. Going forward, more work is needed to strengthen methods of measuring mastery knowledge acquisition in medical trainees before we can optimize mastery learning environments.

Our observations are made on a small sample of residents at one program and may not be generalizable to other settings. All modules were taught by a single author of this article and it would be important to demonstrate consistent results with other faculty members. We plan to collect more data as future trainees and faculty members participate in similar simulations. Video of the participants was not available for this pilot study and should be available for future reliability

testing. The survey used to determine resident confidence was not previously tested. Future study should include measurement tools with evidence to support validity.

CONCLUSIONS

Participation in our pilot case increased novice trainee performance and confidence in the management of supraventricular tachycardia and was generally supported by learners. This format allows for learners to test a new skill in different contexts, which is fundamental to both deliberate practice and the practice of emergency medicine. This pilot study supports the format's feasibility for continued study as a method of optimizing mastery learning environments. However, further work is needed to determine best methods of measuring progress toward mastery learning before investigators can define optimal mastery learning environments.

References

1. Crochet P, Aggarwal R, Dubb SS, et al. Deliberate practice on a virtual reality laparoscopic simulator enhances and quality of surgical technical skills. *Ann Surg* 2011;253:1216–22.
2. Wayne DB, Barsuk JH, Leary KJ, Fudala MJ, McGaghie WC. Mastery learning of thoracentesis skills by internal medicine residents using simulation technology and deliberate practice. *J Hosp Med* 2008;3:48–54.
3. Wayne DB, Butter J, Siddall VJ, Fundala MJ, Wade LD, Feinglass J. Mastery learning of advanced cardiac life support skills by internal medicine residents using simulation technology and deliberate practice. *J Gen Intern Med* 2006;21:251–6.
4. Cordero L, Hart BJ, Hardin R, Manhan JD, Nankervis CA. Deliberate practice improves pediatric residents' skills and team based behaviors during simulated neonatal resuscitation. *Clin Pediatr* 2013;52:747–52.
5. McGaghie WC. Research opportunities in simulation-based medical education using deliberate practice. *Acad Emerg Med* 2008;15:995–1001.
6. Ericsson K. Deliberate practice and acquisition of expert performance: a general overview. *Acad Emerg Med* 2008;15:988–94.
7. Page RL, Joglar JA, Caldwell MA, et al. 2015 ACC/AHA/HRS Guideline for the Management of Adult Patients With Supraventricular Tachycardia: A Report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines and the Heart Rhythm Society. *Circulation* 2016;133:e506–74.
8. Brady WJ, Laughrey TS, Ghaemmaghami CA. Cardiac rhythm disturbances. In: Tintinalli's Emergency Medicine: A Comprehensive Study Guide, 8th ed. New York, NY: McGraw-Hill, 2016.
9. Barsuk JH, Cohen ER, Wayne DB, Siddall VJ, McGaghie WC. Developing a simulation-based mastery learning curriculum: lessons from 11 years of advanced cardiac life support. *Sim Healthcare* 2016;11:52–9.