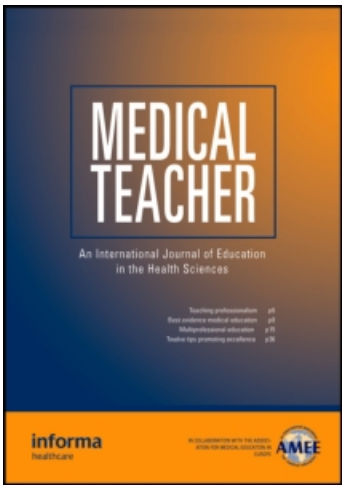

Medical Teacher
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713438241

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Online Publication Date: 01 March 2005

To cite this Article Gordon, David Lee, Issenberg, S. Barry Dr., Gordon, Michael S., LaCombe, David, McGaghie, William C. and Petrusa, Emil R.(2005)'Stroke training of prehospital providers: an example of simulation-enhanced blended learning and evaluation',Medical Teacher,27:2,114 — 121

To link to this Article: DOI: 10.1080/01421590400029756

URL: http://dx.doi.org/10.1080/01421590400029756

Medical Teacher, Vol. 27, No. 2, 2005, pp. 114–121

Stroke training of prehospital providers: an example of simulation-enhanced blended learning and evaluation

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SUMMARY *Since appropriate treatment of patients in the first few hours of ischemic stroke may decrease the risk of long-term disability, prehospital providers should recognize, assess, manage and communicate about stroke patients in an effective and time-efficient manner. This requires the instruction and evaluation of a wide range of competencies including clinical skills, patient investigation and management and communication skills. The authors developed and assessed the effectiveness of a simulation-enhanced stroke course that incorporates several different learning strategies to evaluate competencies in the care of acute stroke patients. The one-day, interactive, emergency stroke course features a simulation-enhanced, blended-learning approach that includes didactic lectures, tabletop exercises, and focused-examination training and small-group sessions led by paramedic instructors as standardized patients portraying five key neurological syndromes. From January to October 2000, 345 learners were assessed using multiple-choice tests as were randomly selected group of 73 learners using skills' checklists during two pre- and two post-course simulated patient encounters. Among all learners there was a significant gain in knowledge (pre: 53.9% ± 13.9 and post: 85.4% ± 8.5;* $p < 0.001$*), and for the 73 learners a significant improvement in their clinical and communication skills (*$p < 0.0001$ *for all). By using a simulation-enhanced, blended-learning approach, pre-hospital paraprofessionals were successfully trained and evaluated in a wide range of competences that will lead to the more improved recognition and management of acute stroke patients.*

Introduction

Although the United States (US) Food and Drug Administration (FDA) approved intravenous (IV) tissue plasminogen activator (t-PA) for ischemic stroke patients within three hours of symptom onset in 1996, most patients arrive in the emergency department (ED) too late to receive this medication. The use of emergency medical services (EMS) personnel decreases time from stroke onset to ED arrival and from ED arrival to brain-scan completion (Morris *et al.*, 2000). Paramedics must rapidly recognize, assess and manage patients with neurological syndromes if more stroke patients are to receive IV t-PA. Yet, among patients diagnosed with stroke by prehospital providers, only 66–77% are discharged from the hospital with a diagnosis of stroke or transient ischemic attack (TIA) (Kothari *et al.*, 1995; Smith *et al.*, 1998; Zweifler *et al.*, 1998). In one study, paramedics missed the diagnosis in 39% of patients discharged with stroke or TIA; the authors concluded that EMS personnel require more substantial stroke training to improve their accuracy in identifying patients with stroke (Smith *et al.*, 1998).

Our center promotes the application of simulation systems to medical education in order to enhance clinical skills and patient safety. This includes the use of standardized patients (SPs) to portray normal and abnormal clinical findings. There are numerous examples of the effective use of SPs in the training and assessment of medical students and house staff, but scant evidence regarding their use with paramedics (Sahni *et al.*, 1997; LaCombe *et al.*, 2000a; Yedidia *et al.*, 2003; Dull & Haines, 2003; Griffith *et al.*, 2003; Learman *et al.*, 2003). In 1997, we developed an eight-hour course on the emergency management of acute stroke that emphasizes hands-on training using paramedic instructors as SPs (LaCombe *et al.*, 2000b). In the current study, we sought to evaluate the improvement in competences of practicing paramedics by assessing their knowledge and skills before and after participation in the course.

Methods

Course development

In November 1996, we convened an advisory committee of stroke neurologists, emergency physicians, cardiologists, general internists, nurses and paramedics. An integral part of course development was the identification of a new neurological assessment tool. The Cincinnati Prehospital Stroke Scale (CPSS), taught in the American Heart Association's Advanced Cardiac Life Support (ACLS) course, takes 30 seconds to perform and effectively screens patients for the presence of stroke, but does not provide prehospital providers with a means for communicating with ED personnel regarding the type and severity of neurological deficits (Kothari *et al.*, 1999). The National Institutes of Health Stroke Scale (NIHSS), used by hospital personnel to quantify stroke deficit, is impractical for prehospital providers

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ISSN 0142–159X print/ISSN 1466–187X online/00/000114–121
DOI: 10.1080/01421590400029756

because it requires the use of speech-and-language cards, a safety pin, and a complex and time-consuming grading system (Yaeger *et al.*, 2000).

We developed a new assessment tool, the Miami Emergency Neurologic Deficit (MEND) Examination, based on the NIHSS and incorporating the CPSS (LaCombe *et al.*, 2000b). We advise EMS personnel to first perform the 'ABCs' (airway, breathing, and circulation) of emergency care and then to perform the 30-second CPSS on scene under 'D' for disability. We advise EMS personnel not to perform the expanded three-minute MEND Exam on scene, but rather to perform it en route if time allows. To assist the prehospital provider, we developed a prehospital checklist, telemetry report sheet and pocket guide. From 1997 to 1999, we trained 20 instructors and 757 prehospital providers as we modified the course with the assistance of medical educators and neurologists.

Course description

The one-day course features a blended-learning approach (Harden & Hart, 2002), and consists of three hours of lectures and five hours of interactive instruction. Didactic sessions cover:

- stroke epidemiology;
- pathophysiology;
- rationale for urgent care;
- the focused neurological assessment (CPSS and MEND Exam);
- five major stroke syndromes (left brain, right brain, brainstem, cerebellum, and subarachnoid hemorrhage);
- stroke mimics;
- prehospital stroke management with emphasis on rapid transport and determining eligibility for t-PA.

Paramedic instructors lead two small-group sessions; the first allows learners to practice the normal neurological examination and the second allows them to practice complete neurological assessments on 'patients'—each learner examines at least four paramedic-instructor SPs portraying one of the five major stroke syndromes. The entire class convenes to review video case scenarios; the students fill out a checklist and telemetry report for each case and review key teaching points with an instructor. The end-of-course review session is in game-show format.

Outcome measures development

To measure the course's effect on the stroke knowledge of paramedics, we developed two similar 20-question multiple-choice tests to be administered pre- and post-course. Question topics aligned with course objectives and included epidemiology, risk factors and pathophysiology, recognition and management of stroke and stroke mimics, and emergency stroke management. We enlisted a consortium of clinical and educational experts and followed a rigorous seven-step development procedure (Millman & Green, 1989).

To measure the course's effect on practical application of stroke knowledge and paramedic skills in identifying and managing stroke patients, we developed four case scenarios enacted by SPs: left hemisphere stroke, right hemisphere seizure with post-ictal hemiparesis, right hemisphere stroke, and left hemisphere tumor with sudden worsening. We developed data collection and scoring forms, trained four SPs and trained four clinician raters. For each SP scenario, we evaluated 31 specific skills using a 51-point skills checklist to evaluate paramedic performance in five areas during the two pre- and two post-course SP encounters: history (5 points), basic exam/CPSS (6 points), expanded/MEND exam (20 points), management (6 points), and ED reporting (14 points) (Figures 1 and 2).

Three lay actors and one paramedic actor served as SPs. A stroke neurologist, an internist, a paramedic and a nurse practitioner served as clinician raters. While the SPs stayed in character throughout the case scenarios, the clinician raters played four different roles: patient caregiver; data informant; emergency physician; and skills rater. The stroke neurologist led a four-hour training session for the SPs and raters, and then each participant received written instructions with specific neurological findings for actors and scripted histories and responses for raters.

Study design

Over the 10-month study period (January–October 2000), 497 paramedics from eight local municipalities attended 27 stroke classes. Of the 497 learners, 345 (69%) took both the written pre-test and written post-test. Skills-study participants did not take the written pre-test due to time constraints. Other learners did not take either the pre- or post-test because they arrived late or departed early.

In 24 classes (average 19 students, range 10–24), we randomly selected two to four learners to participate in the skills study (total 73) using a computer-based random number generator. For logistical reasons, we could accommodate no more than four study participants in any one session, and we chose a random sample due to possible variability in learner experience. The skills-study participants evaluated two SPs in the morning before the course (left-brain stroke and right-brain seizure) and two different SPs in the afternoon after the course (right-brain stroke and left-brain tumor). We informed participants they were going to evaluate SPs with neurologic conditions that may or may not be stroke.

At the beginning of each SP encounter, the paramedic was given a one-line dispatch ('Chief Complaint/Dispatch' in Figure 1) and informed that he or she was on scene and should obtain the history from the patient or patient's caregiver as played by the clinician rater, and obtain all neurological examination data except for pupillary reaction through actual examination of the SP. The rater supplied the following scripted data if asked by the paramedic: history, vital signs, pupillary reaction to light, oxygen saturation, cardiac rhythm and blood glucose (see Figure 1). If the paramedic did not mention that the patient should receive nothing by mouth, the rater (in the role of patient caregiver)

PARAMEDIC STROKE SKILLS STUDY SCENARIO SCRIPT AND SKILLS CHECKLIST, PART 1					
CASE: A (Left-brain stroke) EXAMINEE: EXAMINER: DATE:					
Chief Complaint/Dispatch: Patient has 'confusion' and difficulty speaking. A friend called 911 ten minutes ago at 7:10 AM.					
GENERAL HISTORY	**STANDARDIZED RESPONSES TO EXAMINEE**				
Present Illness	At 7:00 AM, patient sat down to eat breakfast and became confused—didn't recognize me and called a 'fork' a 'knife.' Patient then dropped a glass of juice and couldn't stand up.				
Symptoms (other)	None, including no headache or stiff neck				
Allergies	None				
Medications	Captopril and atenolol				
Past History	Hypertension for many years				
Last Meal	A sip of orange juice about 20 minutes ago				
Events Prior	Morning walk before breakfast				
T-PA HISTORY	**ASKED**	**STANDARDIZED RESPONSES TO EXAMINEE**			
Last time without symptoms	1 ☐	20 minutes ago			
Head trauma at onset	1 ☐	No			
Staring, shaking, seizure	1 ☐	No			
Takes warfarin	1 ☐	No			
Bleeding problems	1 ☐	No			
EXAMINATION	**SCENE**		**TRUCK**		**STANDARDIZED RESPONSES TO EXAMINEE**
	TRIED	**DONE**	**TRIED**	**DONE**	
Vital Signs		☐		☐	Initial: BP 200/110, P 80, R 16; Repeat without treatment: BP 195/110, P 88, R 16
Pupillary reaction		☐		☐	Pupils are normal—equally round and reactive
Hand grasp		☐		☐	Hand grasp weak on right
Foot strength		☐		☐	Right foot weak

Figure 1. Part 1 of the Scenario Script and Skills Checklist for case A, a left-brain stroke. *Notes*: Numbers in the boxes correspond to the number of points (1 or 2) awarded for each skill performed. Skills with no number received no points. See text for abbreviations and description of how scenario was run by the clinician rater.

asked if the patient could receive a drink or take his regular medications (see Figure 1). Although each encounter took place in one location—with the SP reclining on a classroom table—the paramedic was told to comment out loud regarding the imagined location of the patient during each phase of the scenario, specifically informing the rater when the location had changed from the patient's home to the rescue vehicle and when they had arrived in the ED. Once in the ED, the rater played the role of the ED physician and asked for the paramedic's report (see Figure 2).

MEND EXAMINATION	Level of consciousness						Alert
	CPSS	**Speech**	1 ☐	2 ☐	1 ☐	2 ☐	Expressive aphasia—cannot repeat
		Facial droop	1 ☐	2 ☐	1 ☐	2 ☐	Right facial droop/weakness
		Arm drift	1 ☐	2 ☐	1 ☐	2 ☐	Right arm drift
	Questions		☐	☐	1 ☐	2 ☐	Incorrect—cannot state age and month
	Commands		☐	☐	1 ☐	2 ☐	Correct—closes and opens eyes to command
	Visual fields		☐	☐	1 ☐	2 ☐	Right visual field deficit
	Horizontal gaze		☐	☐	1 ☐	2 ☐	Eyes deviated to left, cannot cross past midline
	Leg drift		☐	☐	1 ☐	2 ☐	Right leg barely moves
	Sensory		☐	☐	1 ☐	2 ☐	Decreased sensation to touch and pinch over right arm and leg (relative to left)
	Coordination		☐	☐	1 ☐	2 ☐	Normal coordination all 4 limbs (accurate but slow)

MANAGEMENT	**YES**	**NO**	**STANDARDIZED RESPONSES TO EXAMINEE**
NPO	1 ☐	☐	Patient is due for medicines. Should I give the medicines?
Oxygen 2–4 liters nasal cannula	1 ☐	☐	O2 sat: 98% both pre- and post-oxygen placement
Cardiac monitoring	1 ☐	☐	Normal sinus rhythm with rate 88 (no ischemic changes)
Glucose management	1 ☐	☐	Initial blood glucose: 120; repeat blood glucose: 136
IV normal saline	1 ☐	☐	—
NO hypertension treatment	1 ☐	☐	If treated by examinee, BP decreases to 130/79

Figure 1. Continued.

We evaluated the skills findings after the first five months of the study (part I, $n = 43$). Based on these initial findings, we altered the course by adding history taking and ED reporting to both the skills stations and pocket guides. We then continued the study through calendar year 2000, enrolling 30 paramedics in part II. After completing all stroke classes for calendar year 2000, we analysed the change in cognitive (written) test scores pre- and post-course ($n = 345$) and the change in competence (skills) checklists pre- and post-course ($n = 73$) using a paired t-test with 0.05 as the minimum level of statistical significance. For data management and analysis, we used Statistical Package for the Social Sciences (SPSS 8.0, SPSS, Chicago, IL).

PARAMEDIC STROKE SKILLS STUDY
SCENARIO SCRIPT AND SKILLS CHECKLIST, PART 2:

EMERGENCY DEPARTMENT REPORT FORM

Case: **A (Left-brain stroke)** Examinee: Examiner: Date:

After completion of the 'Management' section on Part 1 of the Scenario Script and Skills Checklist:

1. State, *'I am now the ED physician. Please give me a comprehensive report of the key aspects of the case.'*
2. For each item, place a check in the appropriate box.
3. Note that <u>all</u> components of the prompting questions must be correct in order to score 'Prompted—Correct.'

ITEMS	SPONTANEOUS		If spontaneous response is incomplete, prompt examinee with appropriate question	PROMPTED	
	Incorrect	Correct & Complete		Incorrect	Correct
Time of onset	☐	2☐	When was the last time the patient was known to be without symptoms?	☐	1☐
Speech/ Language	☐	2☐	What was this patient's speech and language function?	☐	1☐
Visual fields	☐	2☐	Did this patient have a visual field deficit, and, if so, what were your findings?	☐	1☐
Motor strength	☐	2☐	Did this patient have any weakness?	☐	1☐
Seizure	☐	2☐	Did this patient have evidence of a seizure at the onset of symptoms?	☐	1☐
Trauma	☐	2☐	Did this patient have head trauma at the onset of symptoms?	☐	1☐
Witness	☐	2☐	Was there a witness at the time of symptom onset and how can I contact this person?	☐	1☐

Figure 2. Part 2 of the Scenario Script and Skills Checklist. *Notes*: Paramedics are first given the opportunity to communicate the important aspects of the case to the ED physician spontaneously. As would happen in a real-life scenario, if the paramedic is not initially forthcoming with important details, the ED physician attempts to prompt a response. Two points are rewarded for spontaneously correct responses and one point is rewarded for prompted correct responses.

Results

Stroke knowledge among paramedics improved significantly after attending the course. Mean scores and standard deviations among the 345 learners who completed pre- and post-course written tests were 53.9% ± 13.9 and 85.4% ± 8.5 respectively ($p < 0.001$). In Part I of the skills evaluation ($n = 43$), mean scores improved significantly for total skills and all individual skills except for management (Table 1). In Part II ($n = 30$), mean scores improved significantly for total skills and all individual skills including management (Table 1). For the entire skills-study population (Parts I and II, $n = 73$), mean scores significantly improved for total skills and all individual skills except for management (Table 1).

The learners did equally poorly pre-course on left-brain versus right-brain scenarios and stroke versus stroke-mimic scenarios and equally well post-course when comparing the scenarios in these ways. Total mean skills checklist scores for the two pre-course scenarios were not significantly different (25.2% for left-brain stroke versus 24.5% for right-brain seizure), indicating that the two cases were the same level of difficulty. Likewise, the total mean skills checklist scores for the two post-course scenarios were not significantly different (74.5% for right-brain stroke versus 72.3% for left-brain tumor).

Discussion

Crocco and colleagues demonstrated that a 45-minute, case-based, stroke-educational module led by either a physician or an ACLS instructor resulted in significant improvement in performance on a 25-question written test by prehospital providers (Crocco *et al.*, 2003). Other investigators have demonstrated the validity of using SPs for both training and assessing competence (Collins & Harden, 1998; Epstein & Hundert, 2002).

Paramedics who attended our interactive, hands-on stroke course demonstrated both improved knowledge on a 20-question written test and improved skills in SP scenarios, including history taking, basic-exam performance (the CPSS, also taught via lectures in ACLS classes), expanded-exam performance (the MEND Exam), and ED reporting. Despite high pre-course test scores in management, these skills also improved significantly after we modified the course with greater emphasis on history-taking and ED-reporting skills.

In part II, we increased the emphasis on history-taking skills in the interactive components of the course and related the history more clearly to the ED report because we felt the mean post-course history score in part I was inadequate, despite statistically significant improvement from 20.2% to 35.7%. As a result, the part-II mean post-course history score improved in a much more meaningful way, increasing from 14.0% to 61.0%. Although the improvement in history-taking skills in part II did not result in comparable improvement in ED-reporting skills (post-course means 61.2% in part I and 64.2% in part II), this may be due to lower baseline ED-reporting skills among the part-II subjects (pre-course means 40.1% in part I and 31.1% in part II). The relatively low final mean scores for history taking and ED reporting probably reflect the fact that history-taking skills are not emphasized in paramedic training as a whole. With emphasis on 'load and go' in most conditions, prehospital assessment consists of initial impression ('scene size-up') and rapid examination.

Our study has several limitations. First, the clinician raters in the skills study were not blinded regarding whether they were observing a pre-test or a post-test. For practical reasons, all pre-tests took place in the morning and all post-tests took place in the afternoon. Second, we did not calculate inter-rater reliability for the clinician raters; we felt calculating

Table 1. Improvement in paramedic skills following an eight-hour stroke course based on performance in standardized-patient scenarios.

Skill tested		Part I $n = 43$ Mean (%) ± SD	Part II $n = 30$ Mean (%) ± SD	Combined $n = 73$ Mean (%) ± SD
History taking	Pre	2.02 (20.2) ± 1.57	1.40 (14.0) ± 1.16	1.76 (17.6) ± 1.44
	Post	3.57 (35.7) ± 2.33	6.10 (61.0) ± 2.62	4.63 (46.3) ± 2.74
Basic exam/CPSS	Pre	4.30 (35.9) ± 2.96	4.47 (37.2) ± 3.22	4.37 (36.4) ± 3.05
	Post	11.23 (93.6) ± 2.24	11.60 (96.7) ± 1.10	11.38 (94.9) ± 1.86
Expanded/MEND exam	Pre	1.98 (4.9) ± 2.21	0.03 (0.1) ± 0.18	1.18 (2.9) ± 1.95
	Post	31.37 (78.4) ± 9.70	32.53 (81.3) ± 5.55	31.85 (79.6) ± 8.23
Management	Pre	9.14 (76.2) ± 2.01	9.47 (78.9) ± 1.78	9.27 (77.3) ± 1.91
	Post	9.30 (77.5) ± 2.76	10.43 (86.9) ± 1.25	9.77 (81.4) ± 2.32
ED reporting	Pre	11.23 (40.1) ± 3.15	8.70 (31.1) ± 2.37	10.19 (36.4) ± 3.10
	Post	17.14 (61.2) ± 4.56	17.97 (64.2) ± 4.03	17.48 (62.4) ± 4.34
Total	Pre	28.69 (28.1) ± 6.70	24.07 (23.6) ± 5.65	26.76 (26.2) ± 6.65
	Post	72.71 (71.3) ± 16.23	78.63 (77.1) ± 11.03	75.18 (73.7) ± 14.51

Notes: Part II took place after course modification to improve the teaching of history-taking skills. CPSS = Cincinnati Prehospital Stroke Scale, MEND = Miami Emergency Neurologic Deficit, ED = emergency department. Analyses performed using paired *t*-test. For all pre- and post-course paired samples, $p < 0.0001$, except for Management (part I, $p = 0.722$; part II, $p = 0.011$; combined, $p = 0.112$).

inter-rater reliability was not appropriate since, throughout the study, no two raters evaluated the same scenario. Third, we tested the paramedics immediately after taking the course. Previous investigators have demonstrated that the skills of paramedics deteriorate with time (Latman & Wooley, 1980; Zautcke *et al.*, 1987). Retention of skills is related to frequency of use and participation in continuing-education programs (Latman & Wooley, 1980). Since EMS stroke calls are urgent yet relatively infrequent, we feel it is especially important that stroke skills training be continuous and repetitive, like ACLS training. In future studies, we hope to evaluate the long-term effects of our course on paramedic performance in the field and the effect of a revised course on the stroke-assessment skills of hospital nurses.

In conclusion, we developed a one-day, hands-on, interactive emergency stroke course that features a blended-learning approach and is practical, transportable, and evaluates the improved performance of paramedic competences. Immediately after taking our course, paramedics significantly improved their abilities to take histories, perform neurological examinations, and communicate with ED personnel about patients with focal brain syndromes. Central to the course is the MEND Exam, a new tool for assessing patients with focal neurological deficits that has applicability in both the prehospital and hospital settings. Despite its eight-hour length, we have implemented our course on a regular basis for six years. To date, we have trained over 1800 paramedics at our site alone and we have held multiple train-the-trainer courses for instructors from all the community-college paramedic programs in our state and for instructors from various agencies, municipalities and hospitals throughout our state and several neighboring states.

Practice points

- A short course that features a blended approach to learning and includes lectures, small-group discussions and hands-on training can lead to improvement in key competences.
- New assessment tools may be developed to facilitate the paramedic's ability to recognize a stroke patient and communicate this information to hospital personnel.
- The use of standardized patients for training and assessment can begin the process of introducing outcomes-based education to the pre-hospital provider population.

Notes on contributors

DAVID LEE GORDON is Professor of Neurology and Medicine and Assistant Director of the Center for Research in Medical Education at the University of Miami School of Medicine. His research and teaching interests include acute stroke, general neurology and medical education. David designed and authored the teaching materials for the course, assisted in data collection, wrote the manuscript and critically reviewed drafts.

S. BARRY ISSENBERG is Associate Professor of Medicine, Assistant Dean for Research in Medical Education and Director of Educational Research and Technology at the Center for Research in Medical Education at the University of Miami School of Medicine. His research interests include the use of simulation methods for training and assessment. Barry assisted in the design of the course and authoring of teaching materials, assisted in data collection and analysis and critically reviewed drafts.

MICHAEL S. GORDON is Director of University of Miami Center for Research in Medical Education, Associate Dean for Research in Medical Education and Professor of Medicine (Cardiology). His lifetime focus has been in the delivery of more effective medical education through advanced technology and simulation. Michael co-designed and co-authored the teaching materials for the course, critically reviewed drafts and was responsible for securing funding for the project.

DAVID LACOMBE is Director of the National EMS Academy in Lafayette, Louisiana. His teaching interests include the training and evaluation of paramedics in competence-based curricula. David assisted in the design of the course and authoring of teaching materials, assisted in data collection and critically reviewed drafts.

WILLIAM C. MCGAGHIE is Professor of Medical Education and Preventive Medicine at the Northwestern University Feinberg School of Medicine. His research interests include the study of deliberate practice in the acquisition of clinical skills. Bill assisted in the design of the course, data analysis and manuscript review.

EMIL R. PETRUSA is Associate Professor of Medical Education at Duke University Medical School. His research interests include performance-based competence assessment. Emil assisted in the design of the course, data analysis and manuscript review.

Acknowledgments

This project was supported in part by the State of Florida Department of Education; *Friends for Life*, a non-profit, volunteer organization supporting research in medical education at the University of Miami Center for Research in Medical Education (CRME); and the Richard L. and Lois S. Werner Family Foundation. The authors would like to thank Patrick Reynolds, MD, for his review of the course and manuscript, Geoffrey Miller, NREMT-P, for his review of the manuscript, standardized-patient actors Mark Siegel, Robert Kranz, Alden McKay and Sarah McKay; clinician rater Alma I. Vega; their outstanding paramedic instructors; and their dedicated administrative staff, especially Jill Hershbein, Eva Blanco and Maria Lorenzo.

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