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Outcomes from extensive training in critical care echocardiography: Identifying the optimal number of practice studies required to achieve competency

Scott J. Millington [a,*], Michael Hewak [b], Robert T. Arntfield [b], Yanick Beaulieu [c], Benjamin Hibbert [d], Seth Koenig [e], Pierre Kory [f], Paul Mayo [e], Jordan R. Schoenherr [g]

[a] Division of Critical Care Medicine, University of Ottawa, Ottawa, Ontario, Canada
[b] Western University, London, Ontario, Canada
[c] Hôpital du Sacré-Coeur de Montréal, Montréal, Québec, Canada
[d] University of Ottawa Heart Institute, Ottawa, Ontario, Canada
[e] Hofstra North Shore–LIJ School of Medicine, Hempstead, NY, USA
[f] University of Wisconsin, Madison, WI, USA
[g] Carleton University, Ottawa, Ontario, Canada

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ABSTRACT

Purpose: Optimal instruction and assessment of critical care ultrasound (CCUS) skills requires an assessment tool to measure learner competency and changes over time. In this study, a previously published tool was used to monitor the development of critical care echocardiography (CCE) competencies, the attainment of performance plateaus, and the extent to which previous experience influenced learning.
Materials and methods: A group of experts used the Rapid Assessment of Competency in Echocardiography (RACE) scale to rate a large pool of CCE studies performed by novices in a longitudinal design. A total of 380 studies performed by twelve learners were assessed; each study was independently rated by two experts.
Results: Learners demonstrated improvement in mean RACE scores over time, with peak performance occurring early in training and a performance plateau thereafter. Learners with little experience received the greatest benefit from training, with an average performance plateau reached at the twentieth study.
Conclusions: Supporting earlier results, the RACE scale provided a straightforward means to assess learner performance with minimal requirements for evaluator training. The results of the present study suggest that novices experience the greatest gains in competency during their first twenty practice studies, a threshold which should serve to guide training initiatives.

1. Introduction

The performance of goal-directed ultrasound exams by physicians at the bedside, commonly referred to as critical care ultrasound (CCUS) in the resuscitative setting, has experienced tremendous growth over the past two decades [1] [2]. Experts have attempted to outline essential underlying skills that relate to CCUS [3], and several medical specialties have included CCUS competencies as mandatory objectives of training [4] [5]. However, extensive study remains to be done in order to determine what specific attributes contribute to CCUS learning, how these abilities develop over time, and what types of training methods best facilitate skill acquisition.

A recent publication by our group established that the Rapid Assessment of Competency in Echocardiography (RACE) scale [6] possessed a reasonable degree of interrater reliability and was capable of detecting improvements in performance for novices developing critical care echocardiography (CCE) skills. Consistent relationships between the different facets of the scale were also established. For example, the quality of inferior vena cava (IVC) images correlated strongly with the ability to assess volume status, an important relationship given that the IVC is one of the main tools traditionally used for this purpose. This validity evidence suggests that the RACE scale is capable of tracking performance over time and has the potential to detect changes during competency development.

In the present study, we used the RACE scale and obtained additional observations from learners as they received extensive CCE training. We controlled for prior experience outside of the training paradigm by examining differences in performance for "low" and "high" experience

* Corresponding author at: Division of Critical Care, University of Ottawa, Box 207, 501 Smyth Road, Ottawa, ON K1H 8L6, Canada.
E-mail address: smillington@toh.on.ca (S.J. Millington).

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learners. Taken together, our results provide evidence for the number of practice studies required to optimize learning, information which is crucial for CCUS program development given the fact that current training guidelines are based largely on expert opinion [7].

2. Materials and methods

2.1. Developing the RACE assessment tool

The methodology used to develop and validate the RACE scale is described in detail elsewhere [6]. In brief, the tool was developed using a series of structured interviews and conference calls with CCUS experts from across Canada and the United States. The finalized RACE tool (Fig. 1) divides assessment into two domains: 1) Image Generation items, assessing image quality for each of the 5 core cardiac views, and 2) Image Interpretation items, assessing the ability for expert clinical judgments to be made based on the images provided. However, it should be noted that the Image Interpretation items reflect an expert's ability to interpret the images generated by a learner rather than the learner's ability to interpret the images they have generated. Thus, it is best understood as indirectly assessing the learner's ability to record useful diagnostic information.

2.2. Mapping the learning curve for point-of-care cardiac ultrasound

In order to explore the early learning characteristics of CCE, a large pool of ultrasound studies was created and rated using the RACE scale. Expert ratings were provided by six intensivists with formal echocardiography training, each responsible for a CCUS program in a major North American academic center. Cardiac ultrasound studies performed by a group of twelve CCUS learners at Western University in London, ON were downloaded from the local archiving system (Qpath Software, Telexy Healthcare, Port Coquitlam, BC). The learners consisted of physician trainees in anesthesia (6), critical care (4), emergency medicine (1), and internal medicine (1), and were selected based on the criteria of: 1) having had basic training in CCUS, but no formal training in echocardiography, 2) currently participating in the local CCUS training program in London, ON, and 3) having completed and archived at least 30 CCE studies. The CCUS training program they were undertaking consisted of three main phases: 1) a two-day CCUS "boot camp", 2) a month-long dedicated CCUS elective, and 3) self-directed longitudinal portfolio building with quality assurance and exam over-reading. All learners whose images were used for the present study were in the third phase of this program.

Subsequently, a series of video clips were extracted by taking the set of available ultrasound studies from each learner and sampling their portfolio of cardiac studies at regular intervals. These studies were then anonymized (with both patient and operator information removed), merged into the larger pool of sampled studies from all learners, randomized, and then distributed to the experts for evaluation using the RACE scale. Each learner had a median of 31 studies extracted (range 28–39) from their total cardiac portfolio (median size of total portfolio was 58 studies, range 37–175). Studies were extracted from the portfolios at regular intervals, selecting roughly every second study to ensure a relatively even sampling from all phases of training.

2.3. Overall RACE scale performance

RACE Scale scores were averaged across raters, as we had previously obtained reasonable degrees of inter-rater reliability between raters [6]. Given that our previous study demonstrated ceiling effects in the Image Interpretation subscale, we did not collapse the two RACE scale subscales. Consequently, the RACE score reflects an average of the subscale items for the Image Generation and Image Interpretation domains for a given session, respectively.

We additionally sought to control for the effects of learner experience. We measured learners' previous ultrasound experience in terms of the total number of CCUS and CCE studies performed prior to the study period, as recorded in the local archiving system. The median number of CCE studies performed prior to study period was 8 (range 2–35), confirming that the learner group was relatively inexperienced in cardiac ultrasound specifically. The median number of CCUS studies

RACE Score Sheet

Point-of-care Transthoracic Echocardiography

Date:	
Trainee:	Evaluator:
Level:	Study #:

Image Generation

	Not obtained	Image quality too poor to permit meaningful interpretation		Suboptimal image quality, but basic image interpretation possible		Good image quality, meaningful image interpretation easy	
PSL	0	1	2	3	4	5	
PSS	0	1	2	3	4	5	
A4C	0	1	2	3	4	5	
SC	0	1	2	3	4	5	
IVC	0	1	2	3	4	5	/25

Overall Quality

	Image quality does not permit meaningful interpretation	Image quality permits meaningful interpretation	
LV function	0	1	
RV function	0	1	
Volume status	0	1	
Pericardium	0	1	/4

Fig. 1. The Rapid Assessment of Competency in Echocardiography (RACE) Tool.