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Original Articles

The Effectiveness of Three Different Curricular Models to Teach Fundamental ECMO Specialist Skills to Entry Level Perfusionists

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Abstract: The dramatic increase in the use of extracorporeal membrane oxygenation (ECMO) over the last decade with the concomitant need for ECMO competent perfusionists has raised questions of how well perfusion education programs are preparing entry-level perfusionists to participate in ECMO. While all perfusion schools teach ECMO principles, there is no standardized or systematic approach to the delivery of didactic knowledge and clinical skills in ECMO. Given this variability of ECMO education across and within perfusion schools, the CES-A exam may provide a metric for comparing curricular approaches. The purpose of this study is to examine three different curricular approaches to prepare new perfusion graduates to master the Adult ECMO Specialist Certification exam (CES-A). We examined three different curricular approaches to prepare new perfusion graduates to master the Adult ECMO Specialist Certification exam (CES-A). We hypothesized that there would be no difference in CES-A pass rate, exam score, Rasch measure, and item category scores between SUNY Cardiovascular Perfusion Program (CVP) graduates who completed SUNY's ECMO Capstone experience (Group III) and CVP graduates who did not select the ECMO Capstone experience (Group II). Further, we studied the performance of a third group of new graduates from an external program that does not offer formal ECMO courses or an ECMO Capstone experience (Group I). Every perfusion graduate in all groups passed the adult ECMO specialist exam. The graduates who as students completed an ECMO Capstone experience (Group III) scored higher on the exam and significantly higher on four exam categories: coagulation and hemostasis ($p = .058$), lab analysis point of care ($p = .035$), and monitor patient and circuit ($p = .073$), and the safety and failure modes ($p = .017$). Overall the median graduate Rasch measures ranked with Group III demonstrating the highest measure to Group I the lowest measures (not significant at $p = .085$). There is a positive educational effect due to CVP graduates completion of the ECMO Capstone experience compared to the program standard ECMO-related curricula in the two perfusion programs participating in this study. From this observation a structured ECMO simulation-based program appears to be equally effective as a traditional, typical lecture-only, clinical perfusion preceptorship, while demonstrating a more satisfactory experience with a higher reported case experience. In this study the standard perfusionist education curriculum prepared the new graduate to be successful on the CES-A exam. The three curricular approaches appear to prepare perfusionist graduates to be successful on the Adult ECMO Specialist exam. **Keywords:** perfusion education, extracorporeal membrane oxygenation, adult ECMO specialist certification exam. *J Extra Corpor Technol. 2021;53:245–50*

The State University of New York Upstate Medical University (SUNY) cardiovascular perfusion education program (CVP) (https://www.upstate.edu/chp/programs/cp/) updated to a master's degree curriculum in 2018 and graduated its first master's degree class on May 1, 2020. A new aspect of the CVP graduate program curriculum includes capstone experiences. (see AmSECToday May–June 2018, p. 6) One of the five major capstone areas of focus is mechanical circulatory assist (MCA) and extracorporeal life support (ECLS) which includes extracorporeal membrane oxygenation (ECMO). The authors believe that the ECMO Capstone curricular activities uniquely meet and exceed the Accreditation Committee for Perfusion Education Approved Perfusion Education

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Curriculum revised in 2010 that include MCA and ECMO (1).

All students in the SUNY CVP curriculum complete 4-credit hours in a dedicated ECMO course and simulation laboratory. In addition, students selecting the ECMO Capstone will complete a 10-credit hour capstone portfolio which consists of written mastery of the body of knowledge and literature, clinical practice via an immersive 7-week ECMO clinical experience at one or more selected clinical affiliates, and a summative oral presentation.

The SUNY ECMO Capstone program recommends the students take the International Board of Blood Management (IBBM) CES-A exam (http://intbbm.org/ces-certification/) upon graduation. The American Society of Extracorporeal Technology (www.amsect.org) offers a certification exam for adult ECMO specialists (CES-A, www.intbbm.org/CES). Riley, Samolyk, Lucas, and Reagor describe the development of the adult ECMO specialist certification exam (2).

The IBBM and CES-A subject matter experts constructed the exam based on the job analysis for the adult ECMO specialist. The verification of the CES-A exam by the IBBM makes the exam a valid and reliable instrument to measure any difference related to an educational effect within the CVP curriculum involving ECMO.

Upon graduation, in addition to being qualified to sit for the American Board of Cardiovascular Perfusion Certified Clinical Perfusionist (CCP, www.abcp.org) examinations, each ECMO Capstone student as part of their studies is expected to complete the CES-A exam as soon as they have secured employment with clinical responsibilities in ECMO. The CES-A exam does not replace the ABCP CCP examinations.

As part of a quality assurance (QA) project for the new SUNY master's curriculum, specifically the ECMO Capstone experience, the SUNY CVP faculty studied the performance of two groups of 2020 SUNY perfusion graduates on the CES-A exam. Additionally, a third group of new graduates from a post-bachelor's certificate program were recruited as an external control group. The results of the QA project are presented in this communication.

METHODS

We studied the hypothesis that there would be no difference in CES-A pass rate, exam score, Rasch measure, and item category scores between CVP graduates who completed the ECMO Capstone and CVP graduates who did not complete the ECMO Capstone experience. Further, we studied the performance of a third group of new graduates from a program that does not offer formal ECMO courses or an ECMO Capstone experience. All three groups received the ECMO content outlined in the AC-PE Perfusion Consensus Curriculum.

Table 1 compares the educational curricular aspect of the three groups of new graduates. A group of volunteer new graduates (Group I, $n = 5$) from an accredited certificate program without formal ECMO coursework or a capstone experience volunteered to take the CES-A exam. Two groups of SUNY CVP new graduates, the ECMO Capstone experience students (Group III, $n = 4$) and a SUNY non-capstone group (Group II, $n = 5$) volunteered to complete the CES-A exam.

This protocol was reviewed by SUNY Upstate Institutional Review Board and deemed exempt for research subjects and exempt for Family Educational Rights and Privacy Act (FERPA) considerations for students (IRB #1617212–1). New graduates in all three study groups signed consent forms agreeing to participate in our educational QA project, to complete the CES-A exam, and to allow their de-identified information and results to be used in the study. The new graduates completed the examination the same week as commencement. The exam was given online using EasyLMS (www.easy-lms.com) and was proctored by video monitoring by the authors using WebEx (www.webex.com).

Group demographics were collected and compared. Group exam pass rate, Rasch measure, total score, and item category scores were compared. Graduates rated the test items as whether the knowledge content was recognized as part of their didactic and/or clinical education.

Statistical analysis was performed using IBM SPSS Statistical Software (Armonk, NY, 10,504). The difference in propensity of demographic nominal information was analyzed with Chi-squared analysis. Ordinal and ratio data were compared between groups with analysis of variance. Tukey stratification was used to find differences if any between the three groups. p values less than .05 were considered significant.

RESULTS

Table 2 compares the new graduate demographics between the three groups before and after the exam. There was no difference between the three groups regarding program cumulative GPA, prior healthcare experience, and pediatric ECMO experience during their program clinical rotations.

New graduates from the outside program reported significantly more clinical ECMO experiences (runs and shifts) than the SUNY non-ECMO capstone new graduates yet both groups earned similar scores on the CES-A exam (Figure 1). New graduates in all three groups in the post-exam survey unanimously agreed that they perceived the exam to be appropriate, set at the right level of difficulty, and they would recommend the exam to their peers.

Table 1. Perfusion education program curriculum.

Curriculum (n Grads)	Degree Earned	Sponsoring Institution	Clinical Perfusion Preceptorship	Scheduled ECMO Lectures	ECMO Immersive Sim Labs	Dedicated ECMO Courses	Capstone Portfolio Preceptorship
Group I (5)	Post-Bacc	Acad Med Center	X	X	–	–	–
Group II (5)	MS	Acad HC Center	X	X	X	X	–
Group III (4)	MS	Acad HC Center	X	X	X	X	X

Group III, CVP ECMO Capstone group; Group II, CVP non-capstone group; Group I, external program reference group with traditional adult ECMO education; n Grads, number of new graduates with the educational activities in the chart; MS, master of science; Post-bacc, post-baccalaureate certificate; HC, healthcare center; Dedicated ECMO catalog course work, university catalog courses; Sim, hands-on high fidelity ECMO simulation with safety drills. Clinical perfusion preceptorship may include clinical ECMO participation.

Table 2. New graduate group demographic parameters.

Parameter	Group	Mean	STDEV	*P* Value
CVP GPA (2.50–4.00)	I (5)	3.56	.22	.753
	II (5)	3.59	.22	
	III (4)	3.67	.19	
Prior HC Experience	I (5)	4/5	–	.533*
	II (5)	4/5	–	
	III (4)	2/4	–	–
Ped ECMO Experience	I (5)	2/5	–	.869*
	II (5)	2/5	–	
	III (4)	1/4	–	
# Clinical ECMO Runs	I (5)	24	14	.010
	II (5)	3†	1	
	III (4)	14	3	
# Clinical ECMO Shifts	I (5)	5	3	.003
	II (5)	2†	4	
	III (4)	47	29	
Agreed Exam Appropriate	I (5)	5/5	–	NS*
	II (5)	5/5	–	
	III (4)	5/5	–	

Group III, ECMO Capstone group; Group II, same program non-capstone group; Group I, external program reference group with traditional adult ECMO education; n, number of graduates in each group; STDEV, one standard deviation; *p* value between Groups less than .05, significant; HC, # of graduates in group reporting healthcare experience before program admission. Listed are the number of students reporting pediatric ECMO experience in school, the # of ECMO runs observed during school, and # of ECMO shifts during school. Appropriate is the # of graduates who agreed the exam was appropriate in the post-exam survey;
*Pearson Chi-Square *p*-value;
†Significantly different from the other two groups by Tukey analysis at $p < .05$.

Figure 1 presents the Rasch measure exam item—candidate map. All 14 study new graduates passed the exam and their scores were spread across the distribution of the 129 CES-A test takers as of May 5, 2020. The candidate Rasch measure means and medians were higher for the ECMO Capstone group (III, $p = .085$) than Groups I and II as displayed in the box plot.

Table 3 compares the total score, number of test items they recognized from their education, candidate Rasch measure, and the 20 exam plan item category scores (see http://intbbm.org/wp-content/uploads/2020/01/100-question-exam-plan-1-24-2020-1.png) between the three groups. Exam total score, Rasch measure, and number of recognized test items reached *p*-value levels less than .105 but not less than .05. Compared to the other two groups, the ECMO Capstone group reported recognizing significantly more concepts on the exam ($p = .009$), scored substantially higher in the coagulation and hemostasis ($p = .058$), lab analysis point of care ($p = .035$), monitor patient and circuit ($p = .073$), and the safety and failure modes ($p = .017$) test item categories.

DISCUSSION

As yet there is no accredited ECMO education curriculum in the world. Perhaps the most recognized authority on ECMO education is the Extracorporeal Life Support Organization (ELSO). ELSO recommends structured on-the-job training including wet labs, bedside facilitation, and tests (3). However healthcare facility based training is variably applied and largely unvalidated.

Daly and coauthors in their 2017 survey of international ECMO facilities reported that perfusionists are frequently technical advisors to ECMO teams and serve as ECMO specialists in about 30% of the responding centers (4). The question of the ability of perfusion education programs to prepare new graduates to be competent to manage ECMO circuits is often discussed but rarely measured, hence the impetus for this study (5).

Perfusion education programs are guided by the AC-PE approved consensus perfusion education curriculum which includes ECMO principles (1). In our observation, the CVP new graduates who completed the ECMO Capstone curriculum performed significantly higher in many question categories of the CES-A exam than the two reference groups of new graduates who did not complete a capstone experience. Every perfusion graduate in this study passed the adult ECMO specialist exam. From this quality check the AC-PE consensus perfusion curriculum seems adequate to prepare perfusion graduates

MEASURE TEST ITEM - MAP – CANDIDATE

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                |
                |  202  203
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           XX   |  015  016  020  107  112  114  117  120  125  134  156
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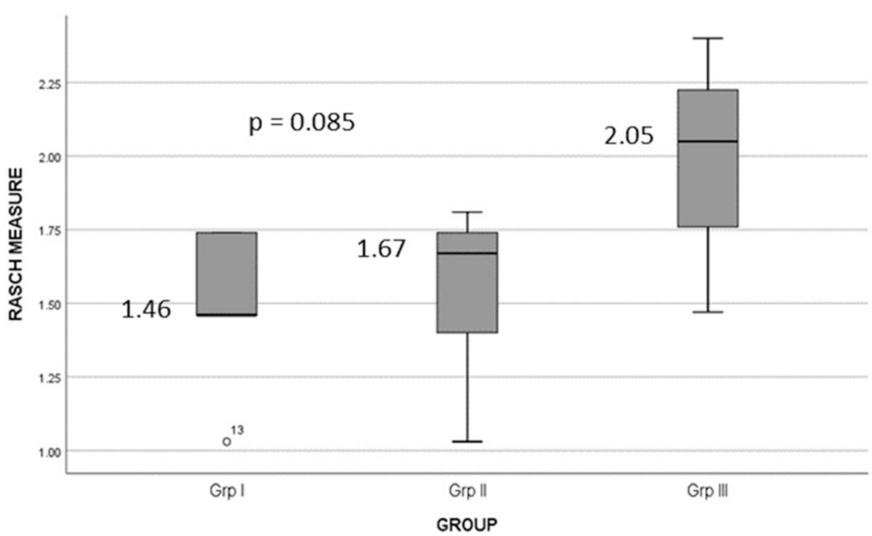

Figure 1. Test item (question)—candidate Rasch measure map listing the ranks for the 14 study new graduates (underlined) compared to the population of all test takers as of April 2020; The test-taker scores are normally distributed and the new graduates appear to be equally distributed across all candidates. T, ± two standard deviations; S, ±1 standard deviation; M, mean. Rasch measure limits are −3.0–4.0. Xs are test questions. The number at the box plot is the median Rasch measure ($p = .085$)

Table 3. Category scores by ECLS capstone group.

Category (n)	Group (n)	Mean	STDEV	*p* Value
Total Score (100)	III (4)	81.0	5.0	.110
	II (5)	74.8	4.9	
	1 (5)	74.0	4.5	
Rasch Measure*	III (4)	1.99	.39	.085
	II (5)	1.53	.10	
	1 (5)	1.49	.29	
Recognized Items (100)	III (4)	95.5	2.4	.009
	II (5)	89.9	5.5	
	1 (5)	70.8†	15.8	
1.1 Terminology (20)	III (4)	16.0	.8	.320
	II (5)	14.6	2.1	
	1 (5)	14.4	1.5	
1.2 Anatomy (5)	III (4)	4.3	1.0	.407
	II (5)	3.4	1.1	
	1 (5)	4.0	.7	
1.3 Physiology (22)	III (4)	15.0	3.2	.795
	II (5)	15.0	4.5	
	1 (5)	14.0	2.6	
1.4 Modes of ECLS (20)	III (4)	16.3	1.3	.456
	II (5)	16.8	.8	
	1 (5)	15.8	1.5	
2.1 Pathology (36)	III (4)	28.5	1.7	.141
	II (5)	27.4	1.7	
	1 (5)	25.8	2.2	
2.2 Pharmacology (14)	III (4)	10.8	1.7	.150
	II (5)	8.8	1.6	
	1 (5)	10.4	1.1	
2.3 Coagulation and hemostasis (16)	III (4)	12.5	1.9	.088
	II (5)	10.0	1.4	
	1 (5)	11.0	1.2	
2.4 Organ preservation (16)	III (4)	13.8	2.6	.156
	II (5)	13.6	.9	
	1 (5)	11.4	2.1	
3.1 Lab analysis POCT (10)	III (4)	8.3†	1.3	.024
	II (5)	5.6	1.7	
	1 (5)	6.0	.7	
3.2 Monitor patient and circuit (50)	III (4)	42.0†	1.4	.060
	II (5)	37.2	4.3	
	1 (5)	35.0†	4.6	
3.3. Initiation and weaning (12)	III (4)	8.0	1.4	.201
	II (5)	9.2	1.6	
	1 (5)	9.8	1.1	
3.4 QA and documentation (24)	III (4)	20.5	1.3	.157
	II (5)	18.6	1.8	
	1 (5)	17.6	2.7	
4.1 Devices (35)	III (4)	26.3	3.1	.788
	II (5)	24.8	3.5	
	1 (5)	25.2	2.6	
4.2 Safety and failure modes (50)	III (4)	44.3†	.5	.024
	II (5)	38.8	3.4	
	1 (5)	39.6	2.7	
4.3 Policies and procedures (44)	III (4)	34.9	4.6	.731
	II (5)	33.2	2.9	
	1 (5)	34.6	2.3	
4.4 Team communication (26)	III (4)	22.7	1.5	.848
	II (5)	22.2	2.2	
	1 (5)	22.2	.8	

The Categories are taken from the CES-A exam plan. Group III, ECMO Capstone group; Group II, same program non-capstone group; Group I, external program reference group with traditional adult ECMO education; N, number of test questions in the exam category.

*Rasch measure is between 0.0 and 4.0; n is the number of exam candidates in each study group. *p* values between Groups less than .05 is significant.

†Group score is significantly different from the other two groups ($p < .05$) by Tukey analysis.

from the two programs in this study to function as ECMO specialists. These results suggest that it may not be necessary for perfusion graduates to take the adult ECMO specialist certification exam.

For the CVP program these observations are a substantial step toward verifying the CVP ECMO Capstone experience. There were several exam categories where non-capstone students performed equally with the capstone students and conversely the capstone students scored higher than the other two groups (Table 3). It was encouraging to the faculty of both perfusion education programs that the non-capstone graduates scored the same in physiology, modes of ECLS, organ preservation, and team communication.

Our observations suggest that successful passage of the adult ECMO certification exam is not reliant on the mode of ECMO curriculum or clinical experience. The non-capstone graduates from the structured ECMO coursework and simulations scored the same as new graduates from the outside program graduates with a reported greater clinical experience. This is encouraging to the simulation world and programs building ECMO coursework with high fidelity simulation (6–8). Perfusion education program faculty and students should immerse in the simulation programs for ECMO specialists, cardiac surgeons, and critical care physicians.

We used the new graduate CES-A results in the exam categories to evaluate the effectiveness of their perfusion ECMO education curricula. We also used video proctoring of the online examination sessions for the new graduate participants in this study. There were no perceived or reported complaints associated with the online video monitoring of the examinees.

We generalized that new graduate success on the certification exam would verify the success of the perfusion education curriculum and the exam should rank new graduates' knowledge of the subject matter. The CES-A exam was constructed by subject matter experts from an ECMO specialist job analysis that yielded more than 93 knowledge, skills, and abilities statements (www.intbbm.org/cesa/). The exam questions are assigned to 16 job-related categories. The exam was shown to rank ECMO specialists based on their knowledge, skills and abilities (2). The ECMO Capstone graduates scored significantly higher in three of the exam categories, a fact that might not completely justify the ECMO Capstone investment. The external program graduates (Group I) recognized significantly fewer of the test question concepts than the other two groups ($p = .009$).

Our QA project is statistically under-powered due to the limited number of CVP students in the Class of 2020. Only four SUNY graduates completed the ECMO Capstone, We considered to wait until we graduate a second class to increase the sample size and statistical power. However, the curriculum in both programs and the CES-A exam are changing, ECMO knowledge, skills, abilities, and attitudes are evolving such that the authors believe there is too much faculty bias to wait for the Class of 2021 to increase the sample size of graduates.

CONCLUSIONS

We make the following observations based on new perfusionist graduate performance on the CES-A Exam in this qualitative observation:

1. There is an educational effect due to CVP graduate completion of the ECMO Capstone experience compared to the basic program standard ECMO-related curricula in the two programs participating in this study.
2. A structured ECMO simulation-based program appears to be equally effective as a typical lecture-only clinical perfusion preceptorship with a higher reported case experience.
3. In this study the standard perfusionist education designs for our two perfusion education programs prepared the new graduate to be successful on the CES-A exam.

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