MEDICAL SCIENCES / DAHİLİ TIP BİLİMLERİ

Evaluation of Simulation-Supported Flipped Classroom Model in the "First Hour of Sepsis Management" Training for 6ᵗʰ Year Medical Students

6. Sınıf Tıp Fakültesi Öğrencilerine Verilen "Sepsis Yönetiminin Birinci Saati" Eğitiminde, Simülasyon Destekli Ters Yüz Sınıf Modelinin Etkinliğinin Değerlendirilmesi

 Aydın Gönülcan[1], Ayça Koca[2], Sinan Genç[2], Ahmet Burak Oğuz[3], Onur Polat[2], Müge Günalp Eneyli[2]

[1]Kırıkkale High Specialization Hospital, Clinic of Emergency Medicine, Kırıkkale, Türkiye
[2]Ankara University Faculty of Medicine, Department of Emergency Medicine, Ankara, Türkiye
[3]U.S. Embassy Ankara, Ankara, Türkiye

Abstract

Objectives: This study aims to evaluate the effectiveness of a non-traditional medical education method, as simulation-based training combined with flipped classroom model compared with traditional didactic lecture.

Materials and Methods: A pre-test was applied to all participants at the beginning of the clerkship and a post- test at the end. Participants were divided into two groups; intervention group and control group. The intervention group had access to guidelines about sepsis and the practical training was provided with a simulation-based scenario session. A traditional lecture was provided to the control group. Last year medical students who were doing their compulsory clerkship of Department of Emergency Medicine at Ankara University Faculty of Medicine between February 1, 2021 and March 31, 2021, were included in the study. SPSS Statistics Version 22 (IBM, USA) was used for statistical analysis. McNemar test was used for categorical variables and Wilcoxon test for ordinal variables in paired samples. Two tailed Mann-Whitney U test and chi-square test were used for inter-group evaluations.

Results: Participants in the intervention group were more successful than the control group considering post-tests results. Success in the difficult questions was higher in the intervention group. Participants trained with sim+ flipped model were more satisfied regarding the training from the control group. No statistically significant difference was found between the groups in other compared parameters.

Conclusion: Students would benefit more from the education given with simulation based training combined with flipped classroom, compared to conventional didactic method.

Keywords: Sepsis management, flipped classroom, medical education, high fidelity simulation

Öz

Amaç: Sepsis, enfeksiyona kontrolsüz bir konak yanıtının neden olduğu hayatı tehdit eden organ işlev bozukluğudur. Tıp fakültelerinde, özellikle sepsis gibi teorik bilgi yükünün yoğun olduğu bir konuda uygulanan eğitimde, geleneksel eğitim dışında bir eğitim yönteminin etkinliğinin ölçülmesi amaçlanmıştır.

Gereç ve Yöntem: Çalışmaya, 01.02.2021-31.03.2021 tarihleri arasında, Ankara Üniversitesi Tıp Fakültesi, Acil Tıp Anabilim Dalı'nda staj yapmakta olan intörn doktorlar dahil edilmiştir. Katılımcılara çalışmanın başında ön-test yapılmıştır. Katılımcılar, blok randomizasyon yöntemi kullanılarak iki gruba ayrılmıştır: Simülasyon tabanlı pratik ile ters-yüz eğitim (n=39) ve didaktik eğitim grubu (n=40). Ters-yüz + simülasyon modelinde, önce sepsis yönetiminin ilk saati ile ilgili kaynaklar verilmiştir, sonrasında simülasyon tabanlı bir senaryo ile pratik eğitim verilmiştir. Diğer gruba da aynı konu ile ilgili didaktik eğitim verilmiştir. Katılımcılara Acil Tıp rotasyonunun sonunda bir son-test yapılmıştır. Verilerin istatistiksel analizi için SPSS Statistics

Gönülcan et al. Flipped Classroom Sepsis Training Evaluation

Ankara Üniversitesi Tıp Fakültesi Mecmuası 2024;77(3):279-284

Version 22 (IBM, USA) kullanılmıştır. Eşleştirilmiş örneklerde, kategorik değişkenler için McNemar testi, ordinal değişkenler için de Wilcoxon testi kullanılmıştır. Gruplar arası değerlendirmeler için ise iki yönlü Mann-Whitney U testi ile ki-kare testi kullanılmıştır.

Bulgular: Gruplar arasında cinsiyet, yaş ve daha önce simülasyon tabanlı eğitime katılmış olma durumu arasında fark saptanmamıştır. Son-testteki puan ortalaması, son-testteki puanın artış ortalaması, son- testte doğru cevaplanan zor soru sayısındaki değişimde; anlamlı bir fark saptanmamış olsa da ters-yüz + simülasyon modeli ile eğitim alan grup, kontrol grubuna kıyasla bu parametrelere göre daha başarılı bulunmuştur. Son-testteki zor sorular içerisinde doğru yanıtlanan soru sayısında, son- testte başarılı olma oranında, ön- teste göre son- testteki başarılı olma durumundaki değişiklikte ve eğitimden elde edildiği düşünülen faydanın değerlendirilmesinde verilen puanda; ters-yüz + simülasyon ile eğitim alan katılımcılar, kontrol grubuna göre istatistiksel olarak anlamlı bir şekilde daha yüksek değerler kaydetmiştir.

Sonuç: Çalışma sonucunda öğrencilerin, tıp fakültelerinde simülasyon tabanlı pratik ile ters-yüz sınıf modeli ile verilecek eğitimden didaktik yöntemle verilecek eğitime kıyasla, daha fazla yarar sağlayacağını gösteren önemli deliller elde edilmiştir.

Anahtar Kelimeler: Sepsis yönetimi, ters yüz sınıf, tıp eğitimi, yüksek gerçeklikli simülasyon

Introduction

Sepsis arises from an unregulated host response to infection, leading to life-threatening organ dysfunction (1-3). Septic shock is a subgroup of sepsis with circulatory and cellular/metabolic dysfunction (4). Sepsis and septic shock pose significant health challenges, impacting millions of individuals globally annually. Early diagnosis and proper management within the initial hours contribute to enhanced outcomes (5). One of the most important conditions for the rapid initiation of treatment is related to the clinician's awareness. Physicians in charge of potential critical patients have to be competent about the diagnosis and the management of sepsis. In order to achieve this, the clinician must have undergone an effective training. Although the teaching/learning methods applied for this purpose and for general medical education are the most important stage in the training of the clinician, there is not yet a consensus in the literature about which method is the most effective (6).

Simulation is one of the important tools used in medical education. Simulation emulates a clinical encounter and is characterized as a method that substitutes or enhances genuine experiences with guided scenarios, reproducing aspects of reality interactively (7). Simulation-based medical education provides authentic training within an enriched setting, fostering experiential learning and reflective practices, thereby better preparing students for actual patient care (6). Moreover, the simulation laboratory provides students a safe environment where they can enhance their learning through the rational application of the skills necessary to efficiently assess and treat an unstable patient (8). In addition to being an effective and well- experienced education method of traditional medicine education; with the developing technology, the use of simulation-based medical education method is increasing due to the safe and supportive environment provided by this method (9-11).

Another important tool used in medical education is the flipped classroom method. The flipped classroom approach is a hybrid teaching/learning technique employed to familiarize students with content prior to participating in in-person sessions. While existing literature endorses the flipped classroom as an educational method, there is insufficient research on its application for skill acquisition (12). Moreover, the flipped classroom is defined as a method that creates the opportunity for the student to learn the theoretical knowledge by herself/himself at home and apply what she/he has learned at school, unlike conventional teaching method (13). The essence of this approach, which liberates the instructor from imparting fundamental information, also demands effort from the learner. This not only fosters increased engagement in individual learning but also cultivates proficiency in utilizing technological tools, establishing a more robust foundation for interaction during instructional sessions (14). The objective of this study is to assess the efficacy of an unconventional medical education method, as simulation based training combined with flipped classroom model compared with traditional didactic lecture of managing first hour of sepsis.

Materials and Methods

Study Design, Setting, and Population

The research conducted at Ankara University Faculty of Medicine has been reviewed and approved by the Human Research Ethics Committee under the reference number I11-662-20. Medical students undertaking the Emergency Medicine clerkship at a Fauclty of Medicine between February 1, 2021 and March 31, 2021 were extended invitations to partake in the study. The study was started with the approval of the university where the study conducted. Informed consent was obtained from the participants.

A pre-test with 25 multiple choice questions related to the first hour management of sepsis was applied to all participants at the beginning of the clerkship rotation. Then, the students were divided into two groups through block randomization; simulation-based training combined with flipped classroom group [sim+ flipped classroom; intervention group (IG)] (n=39)

Ankara Üniversitesi Tıp Fakültesi Mecmuası 2024;77(3):279-284

Gönülcan et al. Flipped Classroom Sepsis Training Evaluation

and didactic training group [control group (CG)] (n=40). The IG had access to simplified guidelines about the first hour of sepsis management and 3 days after the pre-test, the practical training was provided with a simulation-based scenario session. A simulation mannequin [Laerdal SimMan® 3G mannequin (Laerdal, USA)] was used in this tutorial. A traditional lecture 3 days after the pre-test was given by an emergency physician experienced in sepsis management to the CG. Due to the current pandemic at the time of the study the lecture was given online. A public video communication application was used for this process [Zoom®, Zoom Video Communications, Inc. (San Jose, California, USA)]. All of the participants undertook a -25 multiple choice question- post-test at the end of the clerkship rotation. This test was prepared with the same questions as the pre-test, however the placement of the questions and their answers choices differed from the pre-test. A score over 60 out of 100 was considered successful. Besides total scores, the ability to answer correctly to the most difficult questions was evaluated. Criteria for a question to be considered as a difficult one was to have an item difficulty index ≤ 0.29. The item difficulty index of the questions was calculated through the utilization of the Henryson method (15). Out of 25 questions, 4 questions were mentioned as most difficult ones. The Delta value of difficult questions were evaluated for each participant. The delta value was defined as; (number of questions answered correctly out of 4 difficult questions in the post-test)- (number of questions answered correctly out of 4 difficult questions in the pre-test). Along with the post-test, the participants were asked to determine their degree of satisfaction and presumed benefit from the training. Visual analog scale from 0 to 10 was used for this evaluation.

Data Analysis

Statistical analysis of the obtained data was conducted using SPSS Statistics Version 22 (IBM, USA). A power analysis of independent sample t-tests, with an alpha level of 0.05, an effect size of 0.50, and a power of 0.80, indicated a required total sample size of -72. McNemar test was used for categorical variables and Wilcoxon test for ordinal variables in paired samples. Inter-group assessments were conducted using the two-tailed Mann-Whitney U test and chi-square test.

Results

Of the 88 last-year medical students enrolled in the clerkship, 79 willingly joined the study. All participants provided their informed consent. They were randomly assigned to the IC (n=39) and to the CG (n=40). Two students from the CG could not complete the study because of absenteeism on examination day (Figure 1).

The average age of the participants was 25.23 (0.43), 56% of the students enrolled were female and 95% of them did not have any experience in simulation practice (Table 1).

Participants' post-tests' mean scores were higher in both IG and CG. Students who were in the flipped classroom and had simulation practice had a higher increase in post-tests' scores compared to the ones who underwent the didactic lecture. The delta value of the most difficult 4 questions in the IG was found to be significantly higher than the control group (p=0.048). Participants trained with sim+ flipped model were more satisfied regarding the training from the control group (Table 2).
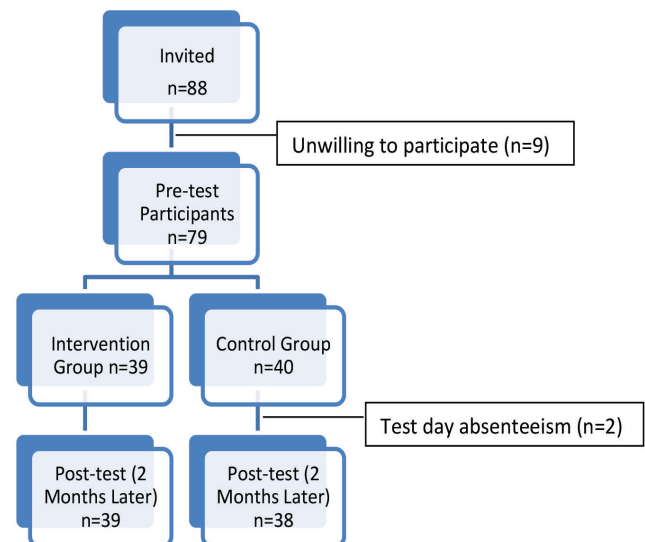

Figure 1: Flowchart of the study

Table 1: Demographic data and previous participation status of the groups			
Parameters	Intervention group	Control group	p value
Age (years) Mean (±SD)	25.23 (±0.43)	25.16 (±0.32)	0.983
Gender, n (%) Female Male	22 (56) 17 (44)	18 (47) 20 (53)	0.497
Previous simulation experience, n (%) No Yes	37 (95) 2 (5)	36 (95) 2 (5)	1.000
SD: Standard deviation			

Gönülcan et al. Flipped Classroom Sepsis Training Evaluation

Ankara Üniversitesi Tıp Fakültesi Mecmuası 2024;77(3):279-284

Table 2. Comparison of the learning outcomes and satisfaction level			
Parameters	Intervention group[a]	Control group[a]	p value
Pre-test score	53.1±8.1	54.7±8.5	0.43
Post-test score	69±12.4	63.9±13.7	0.14
Delta value between the tests	15.9±14.2	9.16±13.4	0.083
Number of correct answers out of the 4 difficult questions			
At pre-test	0.64±0.843	0.68±0.775	0.649
At post-test	2.21±0.894	1.68±1.118	**0.025***
Delta value of the difficult questions	1.564±1.119	1±1.315	**0.048***
Success over test score "60/100"			
At pre-test			
<60/100	27 (69%)	23 (61%)	0.479
≥60/100	12 (31%)	15 (39%)	
At post-test			
<60/100	5 (13%)	13 (34%)	0.03*
≥60/100	34 (87%)	25 (66%)	
Increase in the success over the score "60/100"			
Yes	22	12	0.024*
No	17	26	
Degree of satisfaction from the learning methodology	9.05±1.05	6.7±2.19	<0.001*
[a]Numerical data were presented as mean ± standard deviation and categorical data were represented as frequency (%). *p value <0.05 is considered statistically significant			

Discussion

Sepsis, emerging from a spectrum of endemic and epidemic diseases, has left a deep imprint on the course of human history. Today, sepsis continues to significantly contribute to illness and death on a global scale. The exact number of people affected by sepsis is not known. In addition, the increase in antimicrobial resistance and nosocomial sepsis has been a concern; researches suggest 10 million people worldwide will die from health-related infections each year by 2050's (16).

During the past several years, numerous extensive studies have demonstrated the crucial role of prompt diagnosis and management in the successful treatment of sepsis. The Surviving Sepsis Company provides valuable resources for enhancing the diagnosis and treatment of sepsis, particularly in cases of severe sepsis and septic shock in patients. Nevertheless, based on existing scientific evidence, a substantial portion of patients, around 30% to 40%, does not receive care, and an estimated 20% to 25% of the administered care may be unnecessary or potentially harmful for the patient (17).

Therefore, correct and on-site management of sepsis patients will protect the health system and humanity from the burden of serious morbidity and mortality due to sepsis. For prompt and accurate management of sepsis, health-care providers, especially doctors, should receive an effective and adequate education about sepsis. In the current study, learners trained with sim+flipped classroom method on the management of the first hour of sepsis showed better post-tests results than the CG.

Pre-test and post-tests comparison are instruments useful to measure changes and knowledge gains. According to our results, mean scores in the post-test, were higher in the IC with a mean score of 69 than in the CG with a score 63.1, however this difference showed no statistically significant difference (p=0.14). It has been observed that some of the similar studies in the literature have superior results for IG and some for CG (18,19).

The delta value of difficult questions was found to be statistically significantly higher in the participants in the IG (p=0.048). Similarly, Liebert et al. (20) evaluated the efficacy of a flipped classroom method applied in surgical clerkships of third year medical students. Their results showed a significant increase in mean delta values for each module after flipped classroom training.

Participants were considered successful or unsuccessful according to their scores in the pre-test and post-test respectively ≥60 and <60. No significant difference was found between the IC and the CG for the pre-test (CG= 15, IG= 12) (p=0.479). However, participants became successful in the post-test in both groups (CG= 25, IG= 34) (p=0.03). In a research conducted by Zhao et al. (21) and published in 2020, which the combined problem-based with case-based learning method was

Ankara Üniversitesi Tıp Fakültesi Mecmuası 2024;77(3):279-284

Gönülcan et al. Flipped Classroom Sepsis Training Evaluation

compared with traditional education, the difference between the participants' post-test success was examined. Similar to our study, the group who underwent traditional education was found to be more unsuccessful in the post-test, however the difference between the two groups was not statistically significant (21).

Many studies comparing simulation based education with traditional education have shown medical students to score equivalent or higher on post-tests (22-25). Learning through didactic methods primarily relies on explicit memory, involving the direct recall of previously acquired information. Practical training using simulation facilitates the formation of implicit memory originating from subconscious cognitive processes. Implicit memory is activated through the observation of cues and their association with suitable actions, as opposed to the direct presentation of information through oral or written means. Given the extensive preclinical content, students frequently encounter challenges in determining how to allocate their time and efforts. After experiencing simulations rooted in authentic clinical scenarios, students can grasp the significance and practical relevance of delving more profoundly into the simulated subjects (26).

In comparing teaching/learning methods, besides performance or score improvement it is important to assess whether the method provided appeared beneficial to the pariticipants. For this purpose, the students who participated to the study were asked to score the benefit they thought they received from the training, along with the post-test. We used a visual analog scale, who perceived the benefit at the highest level were asked to give 10 points, and those who perceived the least level of benefit were asked to give 0 point. Considering the mean scores given by the participants (CG= 6.7, IG= 9.05), it was determined that the IG reported a statistically significant higher level of benefit compared to the CG (p<0.001). In a study published by Ramnanan and Pound (27), the students were satisfied with the use of activities based on small group discussions in face-to-face sessions of flipped classroom model; in addition, it was concluded that these sessions helped to increase their motivation to learn, increase their participation level and increase their interest in the subject (27). However, in a study conducted by Fahy et al.(28), certain limitations of the flipped classroom method were identified, especially among reserved students hesitant to engage in discussions with their peers during class sessions.

Study Limitations

This study was conducted at a single center with a limited number of participants; therefore, the results need to be validated in randomized multicenter studies. Another issue that should be emphasized is that traditional education was given online, not face-to-face, due to the current COVID-19 pandemic at the time of the study. This study, centered around sepsis management, consequently, its results cannot be extrapolated to encompass all of medical education.

Conclusion

Although our study was carried out with a limited number of participants (n=77) in a single center, some important evidences were obtained showing that students would benefit more from the education given with simulation based training combined with flipped classroom in medical schools, compared to conventional didactic method. Considering all the parameters in this study, although the flipped classroom method was found to be more successful than the didactic method for the management of the first hour of sepsis, multicenter studies with larger samples are needed on this subject.

Ethics

Ethics Committee Approval: The research conducted at Ankara University Faculty of Medicine has been reviewed and approved by the Human Research Ethics Committee under the reference number I11-662-20.

Informed Consent: Informed consent was obtained from all the participants before conducting the study.

Authorship Contributions

Surgical and Medical Practices: A.G., S.G., A.B.O., M.G.E., Concept: A.G., A.K., M.G.E., Design: A.G., A.K., A.B.O., M.G.E., Data Collection and/or Processing: A.G., Analysis and/or Interpretation: A.G., A.K., S.G., O.P., M.G.E., Literature Search: A.G., A.K., A.B.O., Writing: A.G., A.K.

Conflict of Interest: Each author declares the absence of any commercial affiliations (e.g., consultancies, stock ownership, equity interest, patent/licensing arrangements, etc.) that could potentially create a conflict of interest related to this article.

Financial Disclosure: This research did not receive financial support from any specific grant provided by public, commercial, or not-for-profit organizations.

References

1. Singer M, Deutschman CS, Seymour CW, et al. The Third International Consensus Definitions for Sepsis and Septic Shock (Sepsis-3). JAMA. 2016;315:801.

2. Seymour CW, Liu VX, Iwashyna TJ, et al. Assessment of Clinical Criteria for Sepsis. JAMA. 2016;315:762-774.

3. Shankar-Hari M, Phillips GS, Levy ML, et al. Developing a New Definition and Assessing New Clinical Criteria for Septic Shock: For the Third International Consensus Definitions for Sepsis and Septic Shock (Sepsis-3). JAMA. 2016;315:775.

4. Rhodes A, Evans LE, Alhazzani W, Levy MM, Antonelli M, Ferrer R, vd. Surviving Sepsis Campaign: International Guidelines for Management of Sepsis and Septic Shock: 2016. Intensive Care Med. 2017;43:304-377.

Gönülcan et al. Flipped Classroom Sepsis Training Evaluation

Ankara Üniversitesi Tıp Fakültesi Mecmuası 2024;77(3):279-284

5. Dellinger RP. Cardiovascular management of septic shock. Crit Care Med. 2003;31:946-955.

6. Gordon JA, Oriol NE, Cooper JB. Bringing good teaching cases "to life": a simulator-based medical education service. Acad Med. 2004;79:23-27.

7. Kundra P, Kurdi M, Mehrotra S, Jahan N, Kiran S, Vadhanan P. Newer teaching-learning methods and assessment modules in anaesthesia education. Indian J Anaesth. 2022;66:47.

8. Ten Eyck RP, Tews M, Ballester JM, Hamilton GC. Improved Fourth-Year Medical Student Clinical Decision-Making Performance as a Resuscitation Team Leader After a Simulation-Based Curriculum. Simulation in Healthcare. 2010;5:139-145.

9. Eng AJ, Namba JM, Box KW, Lane JR, Kim DY, Davis DP, vd. High-Fidelity Simulation Training in Advanced Resuscitation for Pharmacy Residents. Am J Pharm Educ [Internet]. April 17, 2014 [a.yer January 10, 2021];78. Access address: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3996391/

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

11. Kim JH, Kim WO, Min KT, Yang JY, Nam YT. Learning by Computer Simulation Does Not Lead to Better Test Performance on Advanced Cardiac Life Support Than Textbook Study. J Educ Perioper Med [Internet]. January 01, 2002 [taken from January 11, 2021];4(1). Access address: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4865364/

12. Wilson KE, Hobbs JR. Innovative use of a flipped-classroom approach to teach fundamental nursing skills. Teaching and Learning in Nursing. 2022;S1557308722000932.

13. Zownorega SJ. Effectiveness Of Flipping The Classroom In A Honors Level, Mechanics-Based Physics Class. :26.

14. Blanie A, Shoaleh C, Marquion F, Benhamou D. Comparison of multimodal active learning and single-modality procedural simulation for central venous catheter insertion for incoming residents in anesthesiology: a prospective and randomized study. BMC Med Educ. 2022;22:357.

15. Hasançebi B, Terzi Y, Küçük Z. Madde Güçlük İndeksi ve Madde Ayırt Edicilik İndeksine Dayalı Çeldirici Analizi. Gümüşhane Üniversitesi Fen Bilimleri Enstitüsü Dergisi [Internet]. January 15, 2020 [taken from May 31, 2021]; Access address: https://dergipark.org.tr/tr/doi/10.17714/gumusfenbil.615465

16. Salomão R, Ferreira BL, Salomão MC, Santos SS, Azevedo LCP, Brunialti MKC. Sepsis: evolving concepts and challenges. Braz J Med Biol Res. 2019;52(4):e8595.

17. Tromp M, Bleeker-Rovers CP, van Achterberg T, et al. Internal medicine residents' knowledge about sepsis: effects of a teaching intervention. Neth J Med. 2009;67:312-315.

18. Riddell J, Jhun P, Fung CC, et al. Does the Flipped Classroom Improve Learning in Graduate Medical Education? J Grad Med Educ. 2017;9:491-496.

19. Angadi NB, Kavi A, Shetty K, Hashilkar NK. Effectiveness of flipped classroom as a teaching-learning method among undergraduate medical students - An interventional study. J Educ Health Promot. 2019;8:211.

20. Liebert CA, Lin DT, Mazer LM, Bereknyei S, Lau JN. Effectiveness of the Surgery Core Clerkship Flipped Classroom: a prospective cohort trial. The American Journal of Surgery. 2016;211:451-457.e1.

21. Zhao W, He L, Deng W, Zhu J, Su A, Zhang Y. The effectiveness of the combined problem-based learning (PBL) and case-based learning (CBL) teaching method in the clinical practical teaching of thyroid disease. BMC Med Educ. 2020;20:381.

22. Bassily-Marcus A, Kohli-Seth R, Petrinko I, Oropello JM, Manasia A, Ellozi S, vd. Knowledge Retention Among Medical Students After Simulation-Based vs Traditional Critical Care Teaching. Chest. 2010;138:197A.

23. Gordon JA, Shaffer DW, Raemer DB, Pawlowski J, Hurford WE, Cooper JB. A randomized controlled trial of simulation-based teaching versus traditional instruction in medicine: a pilot study among clinical medical students. Adv Health Sci Educ Theory Pract. 2006;11:33-39.

24. Wong G, Jenkins C, Yao TJ, Irwin M. A trend toward improved learning of cardiovascular pathophysiology in medical students from using a human patient simulator: results of a pilot study. Adv Physiol Educ. 2007;31:372.

25. McCoy CE, Menchine M, Anderson C, Kollen R, Langdorf MI, Lotfipour S. Prospective randomized crossover study of simulation vs. didactics for teaching medical students the assessment and management of critically ill patients. J Emerg Med. April 2011;40:448-455.

26. Alluri RK, Tsing P, Lee E, Napolitano J. A randomized controlled trial of high-fidelity simulation versus lecture-based education in preclinical medical students. Med Teach. 2016;38:404-409.

27. Ramnanan CJ, Pound LD. Advances in medical education and practice: student perceptions of the flipped classroom. Adv Med Educ Pract. 2017;8:63-73.

28. Fahy BG, Vasilopoulos T, Chau DF. Use of Flipped Classroom and Screen-Based Simulation for Interdisciplinary Critical Care Fellow Teaching of Electroencephalogram Interpretation. Neurocrit Care. 2020;33:298-302.