Simulation-based training for handling extracorporeal membrane oxygenation emergencies

Shingo Sakamoto

Department of Cardiovascular Medicine, Saso Hospital, Hyogo, Japan

Correspondence to: Shingo Sakamoto, MD. Department of Cardiovascular Medicine, Saso Hospital, 5-37 Yubacho, Nishinomiya, Hyogo 662-0964, Japan. Email: gsakamo@gmail.com.

Provenance: This is an invited Editorial commissioned by Section Editor Dr. Lei Huang (Cardiac Center of Tianjin Third-Central Hospital, Tianjin, China). *Comment on:* Zakhary BM, Kam LM, Kaufman BS, *et al.* The Utility of High-Fidelity Simulation for Training Critical Care Fellows in the Management of Extracorporeal Membrane Oxygenation Emergencies: A Randomized Controlled Trial. Crit Care Med 2017;45:1367-73.

Submitted Sep 12, 2017. Accepted for publication Sep 15, 2017. doi: 10.21037/jtd.2017.09.102 View this article at: http://dx.doi.org/10.21037/jtd.2017.09.102

Extracorporeal membrane oxygenation (ECMO) is now widely used in patients experiencing respiratory and/ or cardiac failure who are unresponsive to conventional treatment (1,2). Healthcare staff who provide ECMO treatment are expected to make a speedy and appropriate response to relevant emergencies; however, successful management of ECMO emergencies remains challenging due to the use of highly complex therapies in critical settings. ECMO emergencies place great stress on healthcare staff, which may lead to medical errors that directly influence patient outcomes. Previous research has demonstrated that clinical performance is influenced by the level of stress present during the medical crisis (3). To ensure high quality management of ECMO emergencies, acquiring and maintaining technical, behavioral, and critical thinking skills is essential. Furthermore, as multiple healthcare staff members are involved in ECMO treatment, ensuring good teamwork and communication is important. Notably, however, the presentation of patients with lifethreatening conditions requiring ECMO support occurs rarely in daily clinical practice, except in tertiary ECMO centers. Therefore, it is important that individual hospitals must develop education and training programs for healthcare staff who deal with ECMO emergencies prior to management of actual patients.

Conventional training in the management of ECMO emergencies usually consists of didactic educational lectures and hands-on water-drills. This training method focuses primarily on compiling cognitive knowledge, and acquiring technical skill and behavioral skills (e.g., leadership, teamwork, and communication) is typically difficult to complete through the training. Furthermore, the assessment of a patient's condition and interpretation of monitoring equipment is not required in conventional training; therefore, trainees do not experience the realistic sense of an ECMO emergency. Incorporating simulationbased training is an ideal method to resolve this problem by providing participants with realistic, interactive, team-based training without risking patients' wellbeing. Several recent reports have demonstrated the value of simulation-based training to improve medical staff members' management of ECMO (4,5). Simulation-based training can provide a standardized opportunity for staff members to experience and gain confidence in managing ECMO emergencies (4). In addition, it provides opportunities for interdisciplinary training and improved teamwork and communication among team members. The efficacy of simulation-based training has been reported in several medical fields, including resuscitation, anesthesiology, and thoracic surgery (6-8). Especially, the importance of simulation has been emphasized in thoracic surgical education and has been promoted to the initiatives of various academic societies and industries (9).

Zakhary *et al.* (10) conducted a randomized controlled trial evaluating the utility of high-fidelity simulation training of ECMO emergencies for novice critical care fellows. Twenty-one study subjects who mostly had no experience of ECMO management were randomized into a simulation-

based training group and a water-drills group following a pre-intervention assessment. After randomization, the subjects participated in ECMO emergency scenarios, via high-fidelity simulation training or via water-drills training, followed by debriefing. Simulation training was conducted using a full-body mannequin simulator that was connected to an ECMO circuit, ventilator, central line, and remotecontrolled vital monitor. This combined mannequin and circuit set-up allowed for the simulation of realistic values of circuit pressures, blood flow, and gas flow. The primary outcome was time required to perform scenariospecific critical action, which was the time necessary for the resolution of the emergency scenario. The outcomes were evaluated at 6 weeks and 1 year, respectively, after the training. The study results showed that simulation-based training was superior to water-drills at 6 weeks, and that the superiority was maintained until 1-year. Furthermore, the improved utility of simulation-based training was found not only in emergency scenarios encountered during training, but also in novel scenarios not encountered during training.

These study results support the efficacy of simulationbased training of ECMO emergencies that was reported in previous studies (4,5). However, these previous studies lacked a control group, and training efficacy was assessed only at the end of the training course. The strength of the present study is that this is the first report to show the utility of simulation-based training in the management of ECMO emergencies as compared with a control group (the water-drills group). Furthermore, the study outcome was measured objectively at two points in time (at both 6 weeks and 1-year). Although the sample size was small and a significant number of study subjects dropped out prior to the 1-year assessment, the study suggests that the efficacy of simulation-based training was maintained over 1 year; meanwhile, the water-drills group showed diminished performance with time. A previous study also reported 1-day simulation training can increase knowledge and contribute to the maintenance of knowledge over time (11,12). Vadnais et al. (11) reported that further benefit was gained by repeat exposure to simulation training. In the present study, about half of the subjects experienced ECMO emergencies during the 1-year after the initial assessment. Whether these experiences yielded additional benefits is unknown, though it is expected that regular exposure to simulation training or clinical experience of ECMO enables medical staff to maintain the knowledge and skill needed to manage ECMO emergencies.

Despite the demonstrated value of simulation-based

training for ECMO emergencies, it is important to remember that effective training is the creation of a learning environment that has high-fidelity to the real clinical environment (13). This is achieved by providing enough of the key visual, auditory, and tactile cues to allow the trainee to achieve the necessary level of knowledge. Meanwhile, previous reports comparing the efficacy of high-fidelity versus low fidelity simulation training in resuscitation shows no statistically significant difference between the two methods (14,15). Management of ECMO emergencies requires immediate and appropriate performance with detailed knowledge of cardiopulmonary physiology as well as the complex ECMO system, so high fidelity simulation training may be preferred.

Simulation-based training continues to be widely adopted in many fields in medicine including ECMO emergencies. To date, however, the implementation of training programs has not meant definitively linked to a decreased number or severity of adverse events or improved patient outcomes. Therefore, additional studies are needed to determine whether simulation training improves clinical outcomes and translates to reduced complication rates in patients receiving ECMO.

Acknowledgements

None.

Footnote

Conflicts of Interest: The author has no conflicts of interest to declare.

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Cite this article as: Sakamoto S. Simulation-based training for handling extracorporeal membrane oxygenation emergencies. J Thorac Dis 2017;9(10):3649-3651. doi:10.21037/jtd.2017.09.102

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