

training. If Dr Tolsgaard truly believes this assumption, then what is the value of education research as a field? We argue that an important step in any study design is ensuring the validity of our assumptions. In our case, we tested the assumption that simulation improves knowledge and procedural skill and that those improvements correlate with improved real-world performance. This assumption is crucial in the context of simulation-based training and evaluation in the era of competency-based training.⁴

We agree with Dr Tolsgaard's final point about study design in educational research. Like pregnant patients, trainees are a vulnerable study population. We recognize the value of randomized double-blinded placebo-controlled trials; however, feasibility prevents this approach with medical trainees. We agree that self-assessment and learner satisfaction should not be primary outcomes of education research, and thus we designed our study with a primary outcome of the validated measurement of surgical skills transfer. As educators, we have to be cognizant of the effects of training and assessment on trainee wellness and engagement, so we believe that trainee satisfaction is a necessary component of programmatic assessment.

Finally, a genuine problem in health professions education research is the ability to reach the clinical audience involved in day-to-day trainee teaching. Most clinicians are unfamiliar with the concept of theoretical frameworks. As the *American Journal of Obstetrics and Gynecology* is a clinical journal, we deliberately left out the use of medical education jargon to make our article more accessible to those on the front lines. ■

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You can never be too prepared: ECMO for MCA



TO THE EDITORS: We have read with great interest the clinical review by Zelop et al.¹ These topics were very informative and important for many clinicians. From the perspective of the cardiologist, we have commented on the extracorporeal membrane oxygenation (ECMO) strategy.

As Zelop et al¹ mentioned, even if exceeding 4 minutes after collapsed, perimortem cesarean delivery (PMCD) should be considered for maternal cardiac arrest (MCA). At the same time, we recommend that physicians consider the enactment of ECMO as soon as possible. Recent American Heart Association guidelines admitted ECMO as one of the options for cardiopulmonary resuscitation (CPR), called extracorporeal membrane oxygenation-assisted cardiopulmonary resuscitation (ECPR). ECPR is usually suggested after conventional CPR has

been performed for more than 10 minutes. Considering the fact that the time to establish the system of veno-arterial extracorporeal membrane oxygenation (VA-ECMO) is 10–20 minutes, we should consider ECMO and PMCD decisions for out-of-hospital MCA patients as early as possible.

Obviously although many MCA cases occur in hospital settings and one fourth of those cases were related to anesthetic problems, we should select ECMO candidates promptly. For example, 18.6% of MCA cases (11 of 59) were due to venous and thromboembolic causes according to the Cardiac Arrhythmia Pilot Study (CAPS) trial, and unfortunately, many of them died (10 of 11, 90.9%).² In Japan, a national survey revealed that about 6% of MCA cases were related to a pulmonary embolism. Furthermore, a CHEER

trial about ECPR for pulmonary embolisms revealed early ECPR implementation might be beneficial.³ Therefore, we should not ignore a potential candidate for ECMO, such as a patient with a pulmonary embolism and avoid delaying the implementation of ECPR for one such candidate. Goto et al⁴ developed a relatively new algorithm to initiate VA-ECMO by an emergent physician at the same time as the decision to enact a PMCD, which might be reasonable for many MCAs.

We admit that evidence was scarce, but combining the results from previous ECMO studies and studies about MCA has led us to recommend earlier consideration of ECMO therapy. As mentioned by Zelop et al,¹ incorporating multidisciplinary teams, including an emergent physician, obstetrician/maternal-fetal medicine specialist, anesthesiologist, and cardiologist to diagnose an appropriate candidate for ECMO, is mandatory for MCA to perform time-efficient treatment. ■

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REPLY



We thank Mizuno et al for their interest in our review and acknowledge their astute commentary. As detailed in our review,¹ we have explored extracorporeal membrane

oxygenation (ECMO) and cardiopulmonary bypass as additional interventions that may provide external hemodynamic and/or respiratory support when the etiology of maternal cardiac arrest is potentially reversible. Clinical entities that may be amenable include local anesthetic toxicities unresponsive to lipid rescue, drug overdose, respiratory failure, acute respiratory distress syndrome, cardiomyopathy, and pulmonary/amniotic fluid embolism.

While the American Heart Association incorporated extracorporeal membrane oxygenation resuscitation as an alternative intervention in the 2015 guidelines,² data are limited, especially in the setting of pregnancy. Barriers to implementation of this intervention revolve around pathophysiology and feasibility.

The prothrombotic maternal coagulation system is highly complex, especially when amniotic or pulmonary embolism is superimposed. With either of these clinical entities, the interactions between heart strain and perfusion pressures, anticoagulation, disseminated intravascular coagulation, hypothermic cooling, ECMO, and the presence of a surgical wound lead to an intricate interplay of risks that may culminate in exsanguination, irreversible cardiac failure, permanent brain damage, multiorgan injury, and maternal and perinatal death.³

ECMO resources require time to deploy, and therefore, it is reasonable to incorporate cardiology and cardiothoracic surgery into the multidisciplinary team managing maternal cardiac arrest. Consideration of implementation of this modality should not compromise the initial maneuvers of resuscitation including perimortem delivery. Simulation exercises will facilitate the education of clinical providers to prioritize time-sensitive interventions and enhance teamwork.

While no modality should be dismissed as a possible maternal life-saving intervention, ECMO and cardiopulmonary bypass do present extraordinary circumstances and clinical challenges. The need for national and international registries is truly urgent. ■

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