

# Simulation in cardiac critical care: New times and new solutions

The demand for cardiovascular critical care is on the rise as seen with the aging of the population, and it is reflected by trends in the use of critical care in general!<sup>[1]</sup>

Patient care is complex in postoperative cardiac Intensive Care Unit (ICU) following cardiac surgery which comprises critically ill patients, high emotionality, and fatiguing work schedules. It represents a particular high-stake environment for human error and system failures, and this is thus compounded by the need for simulation training on team function.<sup>[2,3]</sup>

Simulation is an educational tool that improves trainees' knowledge and skills in cardiac critical care such as invasive procedures, management of medical and surgical emergencies, hemodynamic monitoring, and communication skills. A growing body of literature supports the use and effectiveness of low-fidelity and high-fidelity simulators for procedural training in the cardiac ICU.<sup>[4]</sup>

## SIMULATION METHODS

There is a wide diversity of training methods, utilizing equipment ranging from low-fidelity mannequin for skills practice to the high-fidelity models used for scenario-based learning in simulation centers. Scenarios can be tailored to reflect local and critical incidents, and site-specific system errors may be identified.

## COMPUTER-BASED SIMULATION

Computer-based simulation before mannequin-based simulation improves the participants' skills, confidence, and satisfaction, with the activity during the more real-life setting achieved in the mannequin-based simulation [Figures 1 and 2].<sup>[5]</sup>

## WHOLE BODY SIMULATION

Whole body simulation is an efficient means of training a large group of trainees; it allows trainees to experience rare, life-threatening conditions, to make medical errors without harmful consequences to patients, enables faculty to provide feedback, and permits trainees to repeat performances until the educational objectives are achieved.

## SIMULATION SCENARIOS IN THE CARDIAC INTENSIVE CARE UNIT

These have a wide range as follows:

- Airway scenarios for emergency intubation of a patient with a dilated cardiomyopathy and cardiogenic shock, severe asthma, septic shock and severe metabolic acidosis, and recognition of endotracheal tube dislodgement
- Cardiothoracic surgery scenarios for pericardial tamponade postcardiac surgery, end-of-life and organ donation hemodynamic shock and vasopressor usage, hypotension due to disconnected inotropes or for hypertension due to measurement error, etc
- Renal scenarios for hyperkalemia and cardiac arrest due to acute kidney injury, ventricular fibrillation (VF) arrest.

## SIMULATION IN EXTRACORPOREAL MEMBRANE OXYGENATION

Anderson *et al.* were the first to publish simulation for extracorporeal membrane oxygenation (ECMO) and showed a decreased number of errors in ECMO emergencies in those individuals receiving simulation training. ECMO system consists of two components, neonatal mannequin and a standard neonatal ECMO circuit primed with an artificial blood, which are adjusted to reflect the particular clinical scenario. Both venoarterial and venovenous ECMO can be simulated, and

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the cannulae are changed to reflect the appropriate situation [Figure 3]. Simulation specialists adjust the circuit pressures, patient monitoring equipment, and vital signs in real time of a wide variety of clinical scenarios and ECMO emergencies, thereby enhancing the overall realism of the setting.<sup>[6]</sup>

### SIMULATION IN HEMODYNAMIC MONITORING

The critical care and hemodynamic monitoring simulation training system consists of a personal computer, software, and human torso designed to enable to practice insertion of a hemodynamic monitoring catheter; the cardiac monitor displays feeding the catheter through the heart into the pulmonary artery, inflating the balloon at the tip of the catheter, and interpreting the measured pressure and other information obtained.<sup>[7]</sup> There is further evidence that simulation-based training can reduce catheter-related bloodstream infections.<sup>[8]</sup> Special screen calculators in the program may be used to determine hemodynamic, respiratory, ventilator, and renal function indices and echocardiography (ECG) views and pathologies [Figure 4].

Hemodynamic monitoring simulations that incorporate the Laerdal SimMan™ and SimMan™ 3G software (Laerdal China Ltd., Hong Kong, China) partnered with Edwards' Lifesciences providing a range of hemodynamic monitoring solutions. This simulation toolkit includes 19 preprogrammed scenarios to interpret and prudently act upon hemodynamic data developed specifically to challenge cardiac critical care staff or students. For more details, read on Singh and Mehta<sup>[9]</sup> in a brief communication on the subject in this issue.

AQAI SIS models are a growing technology with continuously developing new applications to make all relevant hemodynamic values (e.g., global end diastolic volume and extravascular lung water), which are more realistic on the basis of the actual patient findings. AQAI SIS is a flexible software system which synchronizes the heart rate of the cardiac simulator with the heart rate of the patient, which is a physiological model in cath-lab simulations. AQAI SIS combined with TestChest is a high-end artificial lung simulator with its own models on lung mechanics, gas exchange, and heart-lung interaction properties. The SIS model analyzes all relevant drugs for anesthesia, calculates drug interactions, and generates a simulated bispectral index. This module includes several scenarios, for example, volume loss, severe sepsis, and



Figure 1: Model-driven simulators

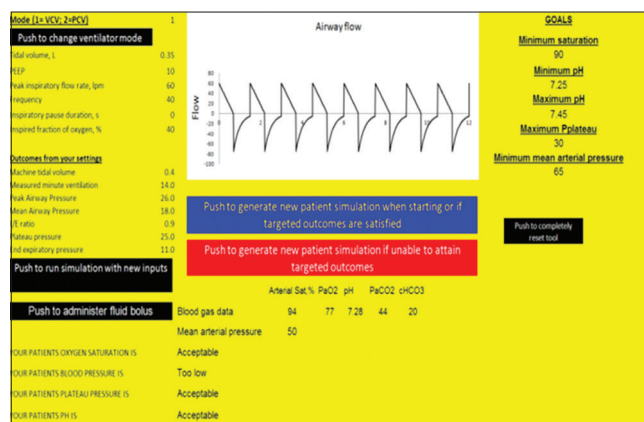


Figure 2: Screen-based simulators

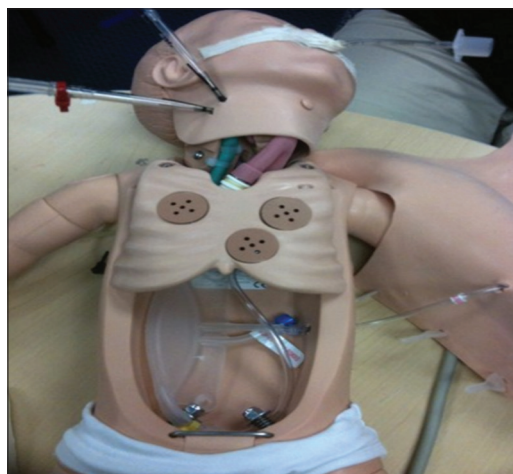


Figure 3: Extracorporeal membrane oxygenation mannequin's chest cavity with neck cannula

ARDS, which is combined with appropriate learning modules.

### SIMULATION IN RESUSCITATION TRAINING

The quality of education, cardiopulmonary resuscitation (CPR) guidelines, and the chain of

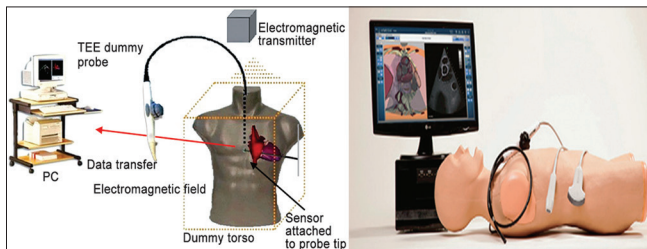
survival all contribute to patient outcome following cardiac arrest. Gavin has discussed the role of task trainers; high- and low-fidelity patient simulators and computer-assisted simulation as teaching tools. Skill-based training offers a simulation-based skill and teamwork training program such as BLS and ACLS [Figure 5].<sup>[10]</sup>

During CPR, cardiogenic scenarios, can be preprogrammed or actively programed. Monitors record chest compression rate, depth of compression, time without compression (hands-off time), palpable pulses, respiratory rate, arterial blood gases, ECG waveforms, ECG artifacts, critical event recognition (e.g., cardiac arrhythmia), and responses to various drug injections. SimMan™ 3G mannequins provide realistic patient experiences for deliberate practice of teamwork, leadership, and communication skills, in high-risk, low-frequency emergencies.

- Crisis resource management and critical care with the use of Pedi Man for pediatric simulation,<sup>[11]</sup> simulation for procedural training on ECG, by Nanda *et al.*<sup>[12]</sup> describe the use of transthoracic echo simulation for aortic valve evaluation in



**Figure 4:** (a) Whole body simulation on SimMan™ 3G for malignant hyperthermia (b-d) Transthoracic echocardiography being taught on VIMEDIX (Photo courtesy by CAE-DSS ImageTech)



**Figure 6:** Parts of a transthoracic echocardiography simulator with mannequin, probe, and computer software (Photo courtesy by CAE-DSS ImageTech)

an exhaustive review [Figure 6] and so does a review on cardiac bleeding disorders with the use of rotational thromboelastography<sup>[13]</sup> and new methods of learning cath-lab procedures with simulators. These reviews are a must-read in this issue [Table 1 and Figure 7].<sup>[14]</sup>

### FUTURE OF SIMULATION LEARNING IN CARDIAC INTENSIVE CARE UNIT

It is a good measurement tool for certification and re-certification. It improves and aids in patient safety and outcomes. Shortly, medical simulation could have a significant the impact or benefit of simulation-based training across the various dimensions.

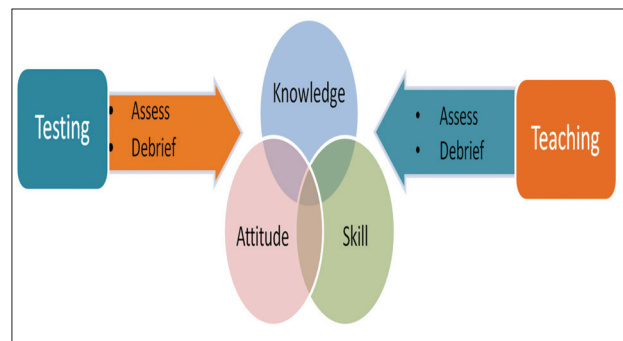
### BARRIERS ASSOCIATED WITH THE DELIVERY OF SIMULATION TRAINING IN INDIA

- Costs of training: Especially for high-end immersive simulation, which requires medical equipment, mannequins, personnel, simulation programing, and facilities
- Lack of trainers.

The only solution to overcome this barrier lies within us, i.e., by motivating ourselves to achieve the best. Sharing the simulation equipment, encouragement



**Figure 5:** Hands-only cardiopulmonary resuscitation using the therapeutic hypothermia machine at a seminar conducted at AIIMS, in 2015 (Photo courtesy by CMET AIIMS, New Delhi)



**Figure 7:** Multiple advantages of simulation training to the students



**Table 1: Advantages of simulators in cardiac critical care**

Students can refine and apply their skills in realistic health-care situations
Learning tailored to the educational needs of students
Allows unlimited creation of situations that might be too dangerous or expensive to perform live
Allows students repeated practice of procedures to reach proficiency
Allows adherence to standard guidelines by reinforcement
Allows evaluation of individual or group performance
No issues of patient safety or confidentiality
The post-training debriefing is the heart of a session on simulation. It maximizes the learning that occurs as a result of the simulated experience
Web simulation can be an excellent tool to complement student training

of more *in situ* simulation in the hospital setting, and training the trainers are the way forward to see much wider use of simulation learning in our country. Debriefing sessions have to be made more realistic and interactive.

## SUMMARY

**“Simulation-based learning is a journey into the uncharted depths of three-dimensional reality of a topic, within one’s own mind and soul. It brings forth a spiritual ecstasy.”**

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## REFERENCES

1. Angus DC, Kelley MA, Schmitz RJ, White A, Popovich J Jr.; Committee on Manpower for Pulmonary and Critical Care Societies (COMPACCS). Caring for the critically ill patient. Current and projected workforce requirements for care of the critically ill and patients with pulmonary disease: Can we meet the requirements of an aging population? *JAMA* 2000;284:2762-70.
2. Frengley RW, Weller JM, Torrie J, Dzendrowskyj P, Yee B,

- Paul AM, *et al.* The effect of a simulation-based training intervention on the performance of established critical care unit teams. *Crit Care Med* 2011;39:2605-11.
3. Rosen MA, Salas E, Wu TS, Silvestri S, Lazzara EH, Lyons R, *et al.* Promoting teamwork: An event-based approach to simulation-based teamwork training for emergency medicine residents. *Acad Emerg Med* 2008;15:1190-8.
4. Weinstock PH, Kappus LJ, Garden A, Burns JP. Simulation at the point of care: Reduced-cost, *in situ* training via a mobile cart. *Pediatr Crit Care Med* 2009;10:176-81.
5. Curtin LB, Finn LA, Czosnowski QA, Whitman CB, Cawley MJ. Computer-based simulation training to improve learning outcomes in mannequin-based simulation exercises. *Am J Pharm Educ* 2011;75:113.
6. Brum R, Rajani R, Gelandt E, Morgan L, Raguseelan N, Butt S, *et al.* Simulation training for extracorporeal membrane oxygenation. *Ann Card Anaesth* 2015;18:185-90.
7. McSparron JI, Michaud GC, Gordan PL, Channick CL, Wahidi MM, Yarmus LB, *et al.* Simulation for skills-based education in pulmonary and critical care medicine. *Ann Am Thorac Soc* 2015;12:579-86.
8. Cohen ER, Feinglass J, Barsuk JH, Barnard C, O'Donnell A, McGaghie WC, *et al.* Cost savings from reduced catheter-related bloodstream infection after simulation-based education for residents in a medical intensive care unit. *Simul Healthc* 2010;5:98-102.
9. Singh A, Mehta Y. Role of simulation in hemodynamic monitoring in cardiac surgery. *Ann Card Anaesth* 2016;18:540-2.
10. Perkins GD. Simulation in resuscitation training. *Resuscitation* 2007;73:202-11.
11. Shetty R, Thyagarajan S. Simulation in pediatrics: Is it about time? *Ann Card Anaesth* 2016;18:506-11.
12. Nanda NC, Kapoor K, Kapoor PM. Simulation for transthoracic Echocardiography of aortic valve. *Ann Card Anaesth* 2016;18:512-6.
13. Gorlinger K, Bhardwaj V, Kapoor PM. Simulation in coagulation testing using Rotational thromboelastometry: A fast emerging, reliable point of care technique. *Ann Card Anaesth* 2016;18:517-21.
14. Aggarwal S, Kiran U, Choudhury A, Ladha S, Kapoor PM. Simulation in cardiac catheterization laboratory: Need of the hour to improve the clinical skills. *Ann Card Anaesth* 2016;18:522-7.

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