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Simulation in the field of transfusion medicine: Scope and utility

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Abstract:

Simulation in medical education has made significant inroads in most of the specialties in some form or the other. Transfusion medicine, as a branch, being a new specialty, is imbibing a few things from the world of simulation and provides immense scope for its utilization, given its broad applicability as well as necessity. In the current Indian scenario of transfusion medicine, wherein the transfusion process has undergone significant changes involving critical steps, with fewer but can be serious complications arising due to the transfusion process, it is desirable for students and the staff involved to practice on the simulators to attain the desired level of competency as it allows the practice of hands-on invasive procedures before performing the actual process. The principles, pedagogies, and educational strategies with their modalities used in health care simulation like case-based scenarios, physical models, computer systems, standardized patients, mannequins, virtual reality, and integrated simulators are all being used and the scope for improvisation is always in the fore with technical advancements. The transfusion and related activities include significant risks, so regular training is essential. The costs are also reasonably high, and focusing on being time-efficient is essential as many scenarios need immediate attention and management. Simulation in transfusion medicine has farsighted returns wherein there is the possibility of defining goals and objectives and ensuring that they could be adjusted to the individual learners as per their knowledge and skill level. The simulations can be set up that can train as well as assess cognitive, affective, and psychomotor domains simultaneously in transfusion using multiple modalities.

Keywords:

Blood administration, simulation, transfusion

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Introduction

"Simulation" is derived from the Latin word "simulare," meaning to copy. The most commonly accepted definitions are "Simulation is a technique and not technology to replace or amplify real-life experiences with guided experiences that evoke or replicate a substantial aspect of the real-world in a fully interactive manner" or "the artificial representation of a real-world process to achieve educational goals via experimental learning."[1]

Why Simulation?

In the current Indian scenario of transfusion medicine, wherein the transfusion process has undergone significant changes involving critical steps, with fewer complications (but can be serious) arising due to the transfusion process. It is desirable for students and the staff involved to practice on the simulators to attain the desired level of competency as it allows the practice of hands-on invasive procedures before performing the actual process. Deliberate practice, i.e. the repetitive performance of intended cognition, skills, or attitude along with regular specific informative feedback to the learners of desirable learning outcomes, is essential for learners to acquire expertise in the field.[2]

Simulation allows errors to continue to their natural conclusion without harming the recipient. It avoids risks to both patients and learners and reduces undesirable interferences. It provides similar learning

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opportunities of the same scenario to be accessed by multiple learners. It allows the planning of clinical cases based on student needs in lieu of patients' availability. It makes it possible to allow exposure to rare and complex clinical situations. The provision of immediate feedback during debriefing sessions is an added advantage. It allows the use of actual medical equipment. It enhances the transfer of training from the classroom to real situations. It also increases retention and accuracy.[3] It provides standards against which to evaluate student performance and enhances identification of educational needs.

Better clinical outcomes are observed as simulation-based medical education improves procedural skills among trainees and may lead to fewer patient complications. They can be designed for novices as well as adult learners who fear humiliation due to a lack of knowledge or skills during the training period. Furthermore, the level of difficulty can be adjusted in simulation-based training. Learning by doing is called experiential learning or action learning, wherein the learner retains up to 90% of what is learned.[4,5]

Why Simulation in Transfusion Medicine?

- Transfusion reactions, as well as donor adverse events, are rare and are short-lived, leaving no or little scope for engaging in teaching or training: so it provides more and ever needing opportunities for learning
- The transfusion and related activities include significant risks, and hence regular training is essential
- Costs involved in procedures involved or transfusion itself is reasonably high
- It allows for repetition and practice in an environment where the patient is not at risk
- The ability to be individualized for learners at different levels and in different environments of the hospital (e.g. donor rooms, apheresis wards, lab side, wards, operating rooms, or intensive care units)
- Focusing on being time-efficient as many scenarios need immediate attention and management
- It helps to bridge the didactic-clinical gap.

Various types of simulators available are listed in Table 1. The principles, pedagogies, and educational strategies with their modalities used in healthcare simulation are as follows:[6]

Table 1: Types of simulators

Simulator type	Examples
Physical (part task trainers)	Plastic-based nondynamic trainers
	Plastic-based dynamic trainer
Computer-based system	SPs
	Simulated environments
Virtual reality trainers	Low-fidelity haptics
	High-fidelity haptics
Integrated simulators	Instructor driven simulators
	Model-driven simulators

SPs=Simulated patients

Modalities

Case-based learning

Written and oral presentations are used to present and review clinical scenarios but do not involve hands-on learning, for example, table-top simulations such as pedigree charts, antigrams, and photographs of gel cards.

Physical models

They usually represent various body parts. Typical examples are intravenous injection training arms or phlebotomy training pads. Even everyday objects can be used as a task trainer, such as oranges for teaching intramuscular injections. Figure 1a and b show a model for capillary puncture and venepuncture trainer.

Standardized patients (warm simulators)

These are individuals who have been carefully selected and trained to portray a patient to teach and/or evaluate the clinical skills of a health-care professional. Since humans are involved in simulation, there is a high degree of realism.[7] For example, patient counseling, transfusion-transmitted infection notification, donor reaction, etc.

Roleplay

A role player is the one who assumes the attitudes, actions, and discourse of (another), especially in a make-believe situation, to understand a differing point of view or social interaction, for example, A patient refusing transfusion.

Computer and web-based simulators

They are generally computer-based simulations with case scenarios or graphical or pictorial representations where students are presented with different choices. Based on the choices made by the student, feedback is provided to the student, for example, monitoring electrocardiogram or other physical parameters during the donation or therapeutic apheresis procedures, identifying adverse reactions, monitoring electrolyte abnormalities, etc. Figure 2 shows a computer system software.

Mannequin-based simulators (cold simulators)

Computer-controlled full-body simulators can mimic various normal and deranged physiological mechanisms. Mannequins simulate critical medical, surgical events, or common emergency scenarios to teach the students and train them to diagnose and manage the simulated

patient. They can be used for soft (nontechnical) skills such as leadership, decision-making, and communication in scenarios such as vasovagal reactions, massive and transfusion protocol (MTP) activation [Figure 3].

Hybrid simulators

This simulation combines two or more simulation modalities to produce a more realistic simulation experience. Usually, simulated patients, along with any wearable device, are involved in this form of simulation. For example, a healthy donor is wearing a device for a lump in the neck or vein on the arm. Here, the students learn a skill (clinical examination of the vein with needle insertion), history taking and communication skills.[8] Figure 4 shows a simulated patient wearing a collar on the neck.

Integrated simulators

In integrated simulators, a manikin is connected to a computer that controls the physiological mechanism and provides outputs on the monitor through graphic displays. Integrated simulators are classified as model and instructor driven. Model-driven simulators like SimMan are more resource intensive, while instructor driven are not and consists of a predefined computer algorithm.[9]

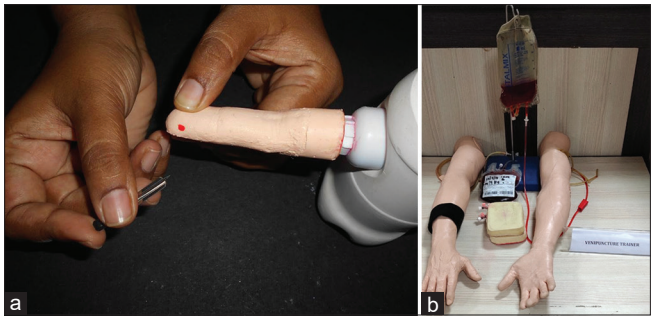

Figure 1: (a) Capillary puncture model. (b) Venipuncture trainer

Figure 3: A computer-controlled mannequin (whole body)

Virtual reality, haptic simulators, and virtual environments

Virtual reality (VR) computer is a term applied to simulated environments that can replicate physical presence in places in the real world and imaginary worlds. Haptics uses technology that stimulates the senses of touch and motion. It is helpful to reproduce in remote operation or computer simulation the sensations that would be felt by a user interacting directly with physical objects. For example, the ability to see and interact in the workspace in the laboratory or donor management area, understanding workflow or a transfusion reaction in the ward with the revival of the patient.[10] Haptics is the word used to describe the feel of tissue resistance and uses technology that stimulates the senses of touch and motion.[11] It is helpful to reproduce in remote operation or computer simulation the sensations that would be felt by a user interacting directly with physical objects. VR trainers can be of low-fidelity or high-fidelity haptics and are

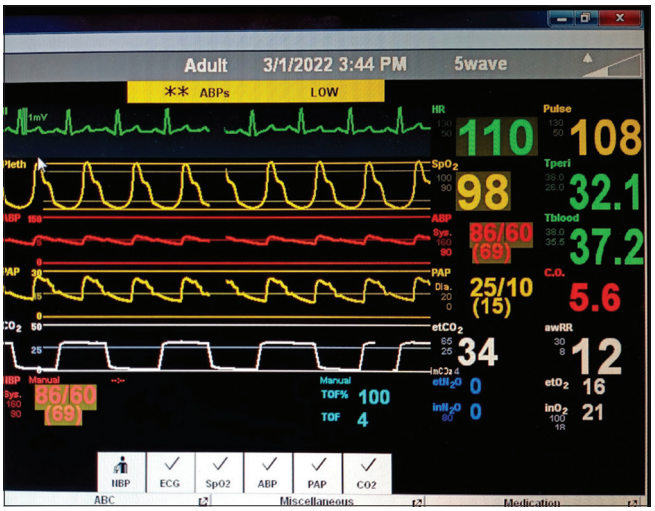

Figure 2: A computer-based simulator showing various parameters

Figure 4: A standardised patient wearing a neck collar

available for minimally invasive surgical procedures. In the immersive models, the trainees usually use a wearable device that creates an entirely virtual environment around them, like an operation theatre, where they can interact. This kind of simulation can be recorded and used to provide detailed feedback about the performance.[5]

Multimodal formats

The use of multiple modalities of simulation in the same simulation activity; A mixture of textual, audio, and visual modes in combination with media and materiality to enhance the realism of the simulation encounter, for example, activation MTP in polytrauma case.

Simulated Environments

The environment in simulation laboratories is made to recreate the clinical setting to develop clinical skills. By doing this, contextual fidelity is improved, distractions are minimized, students are taken closer to the real world, and routine functioning of real-world clinical settings is not impaired due to teaching and learning.[12]

Fidelity is defined as the degree to which the simulation replicates the real event and/or workplace; this includes physical, psychological, and environmental elements. It can be classified as:

Conceptual fidelity

Ensures all elements of the scenario or case realistically relate to each other so that the case makes sense to the learners (e.g. vital signs reflect the diagnosis).[13]

Physical/environmental fidelity

Factors include environment, manikins, room, moulage, equipment, noise, and/or props.

Psychological fidelity

Factors such as emotions, beliefs, and self-awareness of participants; the extent to which the simulated environment evokes the underlying psychological processes necessary in the real-world setting for the participant.[14]

Functional fidelity

The degree to which the equipment used in the simulation responds to the participant's actions; for example, a static ventilator would offer low functional fidelity compared to a working ventilator in a simulation requiring a ventilator alarm.

Based on their resemblance to reality, simulators are classified into low fidelity, medium fidelity, and high fidelity.[15]

Debriefing is conducting a session after a simulation event where educators/instructors/facilitators and learners re-examine the simulation experience to move toward assimilation and accommodation of learning to future situations. Debriefing should foster the development of clinical judgment and critical thinking skills.[16]

Current Applications

Education and training

Blood administration

Not all medical nursing staff are trained in blood administration practices. However, being cognizant and competent of it is paramount to being an emergency medical intervention. The participant's knowledge will decline over time, even after specific training on safe transfusion practices. Work environment, workload, and distractions can deleteriously affect safe transfusion practices. The blood transfusion process before work generally being institution specific, simulation template could be used for a blood transfusion management simulation experience as an orientation for even professionals who are well versed with it. Blood transfusion management competency can provide a safe and valuable learning experience to all involved health professionals, in addition to providing a platform for interprofessional education.[17-19]

Transfusion reactions

A simulated approach can be used to teach an interprofessional team of healthcare students to recognize and manage a blood transfusion reaction. Postsimulation debriefing allows students to discuss, reflect, assess, and receive feedback on their performance. High-fidelity, mannequin-based, immersive scenarios with realistic physical surroundings and scenario components have been designed to promote student engagement and learning in a simulated hospital environment.[20,21]

Massive transfusion protocols

A life-threatening hemorrhage requiring massive transfusion can occur in various clinical situations, unexpected intraoperative and postoperative hemorrhages, traumatic injuries and extracorporeal membrane oxygenation with significant mortality and morbidity, making a rapidly organized response to the massive hemorrhage critical to improving outcomes. This simulation provides the emergency/Operation Theatre(OT) and blood bank staff with the actual setting where the complex process of MTP could be practised in a safe environment. It allows the learners to improve skills and provide feedback resulting in process changes that may improve patient outcomes in any hospital area that triggers the MTP.[22,23]

Phlebotomy

Although phlebotomy, the taking of blood from peripheral veins, is a routine procedure, it can cause pain and carries a small risk of serious complications, which is all the more unwanted in donors as it may leave them demotivated for subsequent donations. Moreover, for component preparation, a clean atraumatic puncture is required to ensure the quality of collected products. Phlebotomy is one of the easiest and more straightforward procedures to start practising or adopting simulation.[24]

Exchange transfusion

Double volume Exchange transfusion is a risky procedure that can result in complications like arrhythmias, cardiac arrest, air embolus, metabolic derangements like hypocalcemia and hypoglycemia, and hematological complications, such as thrombocytopenia, as well as an infection. Providers in neonatology need to master this life-saving procedure. However, because of prevention by RhIg and effective phototherapy, these procedures have come down, thereby not enough opportunities for the residents to be trained for this procedure. This model can also be easily adapted to teach a dilutional exchange transfusion required for the newborn's polycythemia. This can be made more sophisticated by adding the suggested complications.[25]

Intrauterine transfusion

Again, intrauterine transfusion (IUT), an uncommon procedure requiring high expertise, has been practised on a low-cost, high-fidelity model to provide natural tissue resistance and represents a sonographically accurate intrahepatic fetal blood transfusion training tool. The model was constructed from a boneless chicken thigh folded over a Penrose drain placed in a water-filled snap-lock lid container and covered by melted ballistic gel to simulate the fetal intrahepatic vessel.[26] Commercial and homegrown simulators exist for IUT and chorionic villus sampling. These simulations in invasive fetal procedures benefit residents, are included in continuing medical education programs, and are incorporated in the maintenance of certification programs.[27]

Counseling

Standardized patients/donors have been commonly used in training for counseling skills, be it predonation, postdonation counseling notification, transfusion medicine consults, and elsewhere. Commonly actors are trained to respond in a specified manner and are routinely employed to teach this essential skill to people working in blood safety.

Donor reactions

As donor reactions and rare and short-lived, it is tough to observe them and learn their management for beginners or in planned classes or assessments. Hence usually, participants are trained to fake or enact a donor reaction and managing them has been utilized in lectures and workshops regularly. The exercise is also frequent in assessment and generally utilizes standardized patients/donors. Mannequins-based Simulators can be utilized for creating apneic episodes.

Others

Full body mannequins simulators can be utilized to teach and assess respiratory care in transfusion reactions like transfusion-related acute lung injury or anaphylaxis. A peripheral nerve stimulator can be used for showing hypocalcemic signs and symptoms and diagnosis of Guillain-Barre Syndrome for plasmapheresis. Mannequins simulators can be utilized for hemorrhage control systems and airway management. Neonatal simulators is a neonatal resuscitation/monitoring simulators.[28]

Assessment and licensure/certification

Various scenarios like donor reactions, transfusion reactions, communication skills, examinations, and working in a time to name a few, are regularly created for assessment either for students or for certification/licensing of various aspirants who intend to work or get into a career in transfusion medicine services. As these scenarios in blood transfusion are generally rare and unanticipated, simulation has been the cornerstone for recreating and utilizing them. However, these modes of assessment should be ensured for validity and reliability. Part-Task Trainers like phlebotomy arm or airway simulators can be used to assess skills. A believable scenario where a transfusion mix-up, failure to cross-check blood products before transfusion, or proceed with surgery without confirming that blood is available, blood transfusion advance directive in a Jehovah's witness patient and discussion, etc., with standardized patients in a simulated environment have all been created and utilized for assessment/certification.

Future

The onset of the pandemic has posed many challenges in continuing the teaching–learning environment, including the skills laboratory. There is radical change and adaptation of simulation-based learning. In the future, hybrid simulation, more VR tools, and digital three-dimensional (3D) models combined with artificial intelligence will be the learning modality as this form of learning can be customized, personalized to the learner, and provides a timeless learning frame. Combining multiple simulation modalities enhances the reality of a scenario by recreating the environment, physiology, emotions, and dialogue of an actual patient encounter. By combining

the expertise of only Standardized Patient Program with human patient simulators, ultra-realistic hybrid simulation scenarios can be offered. For example, a manikin may present as the patient/donor who has an adverse reaction, while the standardized patient will role-play as the family member who is distressed. Learners must address both the needs of the patients and the needs of the family to heighten the quality of the clinical encounter. Digital 3D models offer learners and clinical providers a 3D approach to anatomy and can be utilized for central line insertion, intubation, etc.[29] AI-based virtual assistants, inpatient care bots, and AI-assisted robots can be utilized to handle the various situations encountered during apheresis, exchange, or blood product administration.

Currently, educators watch trainees' performance in a clinical simulation scenario to generate feedback on their behavior. As complex algorithms come to a better understanding of human speech, actions, and nonverbal communication, they can provide highly granular reports on learners' decisions. Imagine capturing fleeting learner microexpressions or delays in decision-making and using this level of data to further inform and strengthen debriefing. The AI-driven Speech Engine can enable simulators to listen and respond independently. Hence they can be used to practice healthcare communication. Advanced cloud-based speech recognition, natural language processing, and speech synthesis give scenario-specific answers to thousands of medical interviewing questions and countless variations.[30] The simulations can be set up that can train as well as assess cognitive, affective, and psychomotor domains simultaneously in transfusion using multiple modalities.

In conclusion, simulation in transfusion medicine has farsighted returns wherein there is the possibility of defining goals and objectives and ensuring that they could be adjusted to the individual learners as per their knowledge and skill level. It provides vast opportunities to apply knowledge into practice and uncovers any deficiencies in understanding with immediate feedback and correction for a wider population. The skills required for transfusion are teamwork and are fundamental skills that most health-care providers should know; simulation provides the best opportunity for training. It provides an educational experience that promotes the appropriate attitudes, communication skills, and team building and allows instructors to challenge the learners to explain their actions and possibly research/explore strategies supportive of their proposed solution.

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Conflicts of interest
There are no conflicts of interest.

References

1. Gaba DM. The future vision of simulation in health care. Qual Saf Health Care 2004;13 Suppl 1:i2-10.
2. Motola I, Devine LA, Chung HS, Sullivan JE, Issenberg SB. Simulation in healthcare education: A best evidence practical guide. AMEE Guide No. 82. Med Teach 2013;35:e1511-30.
3. McGaghie WC, Issenberg SB, Petrusa ER, Scalese RJ. A critical review of simulation-based medical education research: 2003-2009. Med Educ 2010;44:50-63.
4. McGaghie WC, Harris IB. Learning theory foundations of simulation-based mastery learning. Simul Healthc 2018;13:S15-20.
5. Ker J, Bradley P. Simulation in Medical Education. Underst Med Educ Evidence, Theory Pract Second Ed 2013;175-92. Available from: https://onlinelibrary.wiley.com/doi/full/10.1002/9781118472361.ch13. [Last accessed on 2022 May 20].
6. Lopreiato JO. Healthcare Simulation Dictionary. Rockville: Agency for Healthcare Research and Quality; 2016.
7. Barrows HS. An overview of the uses of standardized patients for teaching and evaluating clinical skills. AAMC. Acad Med 1993;68:443-51.
8. Nguyen LN, Tardioli K, Roberts M, Watterson J. Development and incorporation of hybrid simulation OSCE into in-training examinations to assess multiple CanMEDS competencies in urologic trainees. Can Urol Assoc J 2015;9:32-6.
9. Kneebone R. Simulation in surgical training: Educational issues and practical implications. Med Educ 2003;37:267-77.
10. Tsang HC, Truong J, Morse RJ, Hasan RA, Lieberman JA. The transfusion service laboratory in virtual reality. Transfusion 2022;62:713-5.
11. Pai D. Use of simulation for undergraduate medical education. Int J Adv Med Heal Res 2018;5:3.
12. Bradley P, Postlethwaite K. Setting up a clinical skills learning facility. Med Educ 2003;37 Suppl 1:6-13.
13. Rudolph JW, Simon R, Raemer DB. Which reality matters? Questions on the path to high engagement in healthcare simulation. Simul Healthc 2007;2:161-3.
14. Dieckmann P, Gaba D, Rall M. Deepening the theoretical foundations of patient simulation as social practice. Simul Healthc 2007;2:183-93.
15. Maran NJ, Glavin RJ. Low- to high-fidelity simulation – A continuum of medical education? Med Educ 2003;37 Suppl 1:22-8.
16. Bae J, Lee J, Jang Y, Lee Y. Development of simulation education debriefing protocol with faculty guide for enhancement clinical reasoning. BMC Med Educ 2019;19:197.
17. Hogg G, Pirie ES, Ker J. The use of simulated learning to promote safe blood transfusion practice. Nurse Educ Pract 2006;6:214-23.
18. Campbell DM, Poost-Foroosh L, Pavenski K, Contreras M, Alam F, Lee J, *et al.* Simulation as a toolkit-understanding the perils of blood transfusion in a complex health care environment. Adv Simul (Lond) 2016;1:32.
19. Morgan S, Rioux-Masse B, Oancea C, Cohn C, Harmon J Jr., Konia M. Simulation-based education for transfusion medicine. Transfusion 2015;55:919-25.
20. Blood Transfusion Reactions | Simulation Canada; 2015. Available from: https://www.sim-one.ca/scenario/blood-transfusion-reactions. [Last accessed on 2022 Jan 17].
21. Rhees JR, Scheese CH, Ward D, Hollister L, Blamires TL, Wilkins DG, *et al*. Clinical practice simulation for blood transfusion reactions: An interprofessional approach. Am Soc Clin Lab Sci 2015;28:224-31.
22. Ho AM, Ho AK, Mizubuti GB. Computer simulation of transfusion with different blood product ratios in modern massive transfusion protocols. Med Hypotheses 2019;125:10-5.
23. Kamerer JL. Massive transfusion protocol simulation: Compound

femur fracture and hypovolemic shock. Simul Healthc 2012;7:196-200.
24. Taniguchi J, Matsui K, Araki T, Kikawa K. Clinical training: A simulation program for phlebotomy. BMC Med Educ 2008;8:7.
25. Rosen O, Angert R. Exchange transfusion simulation models: A technical report. Cureus 2019;11:e5317.
26. Nourallah G, Ryan G, Abbasi N, Seaward G, Keunen J, Van Mieghem T, *et al.* Development of a training model for teaching intrauterine fetal blood transfusion. J Obstet Gynaecol Can 2022;44:931-3.
27. Satin AJ. Simulation in obstetrics. Obstet Gynecol 2018;132:199-209.
28. Epps C, Lee White M, Tofil N. Mannequin based simulators. In: Levine A, DeMaria S, Schwartz A, Sim A, editors. The Comprehensive Textbook of Healthcare Simulation. New York: Springer Science; 2013. p. 209-32.
29. Cercenelli L, De Stefano A, Billi AM, Ruggeri A, Marcelli E, Marchetti C, *et al*. AEducaAR, anatomical education in augmented reality: A Pilot experience of an innovative educational tool combining AR technology and 3D printing. Int J Environ Res Public Health 2022;19:1024.
30. Simulation Manikin for Nursing and Medical Training – Alex by PCS. Available from: https://www.pcs.ai/alex/. [Last accessed on 2022 Jun 06].