Editorial

Amalgamation of artificial intelligence and simulation in anaesthesia training: Much-needed future endeavour

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The art of educating the trainees is always challenging to the medical fraternity. Teaching is much more challenging in the speciality of anaesthesiology, as there are multiple consequences to the administered drugs during the perioperative period, and the patient with pre-existing comorbidities could exhibit unforeseen physiological responses. Recent times have seen exponential growth in the number of trainees admitted to all medical specialities. The lack of infrastructure and teaching faculty to deal with such large numbers of trainees has compromised their teaching and training to a large extent. A well-designed simulation-based learning experience (SBLE) can offer a helpful solution and play a pivotal role in imparting quality training to the admitted trainees. To acquire good clinical competency, trainees in anaesthesiology will require sufficient opportunities to undergo SBLE, which would enable them to acquire knowledge and skills and understand the consequences of their actions in real-time patient management.

High-fidelity simulators need to be configured to run different case scenarios. For these scenarios to be effective, robust planning is required. Planning of a simulation-based case scenario (SBCS) should be based on trainees' existing knowledge, intended outcomes, context and learning objectives.

Writing and developing an SBCS: The first step in implementing an SBCS is to write a script. It is desirable to consider the following points for writing the script of an SBCS: i) define the outcomes, ii) determine the context, which includes type of patient or case scenario, equipment, fidelity (level of realism should be that which promotes achievement of the expected learning outcomes), iii) define learning objectives by using SMART template, where S = specific (What goal you intend to achieve? Why should you achieve this goal? Who are required to achieve the desired set goal?), M = measurable (What are the parameters that will be used to measure the progress and achievement of the set goal?), A = achievable (Are the goals achievable through simulation? Do you need additional skills to achieve the goals), R = relevant (What is the need to achieve the goal? What will be the impact on the learners of achieving the goal?) and T = timely (Will you be able to achieve the learning objectives in the set time for the case scenario?). Once the simulation scenario script is written, the simulation scenario is ready for development, which is the second step. Preparation for developing a case scenario requires case, case stem, flow, role and scripts, resources, pre-briefing, debriefing and rehearsal (dry run).[1]

Existing weaknesses in SBLE: Currently, during simulation-based learning, the operator feeds the parameters manually according to the participants' responses, making the simulation exercise unrealistic for the participants. Secondly, the use of SBLE is limited only to pre-fed case scenarios already known to the trainees/participants. The inability to create new case scenarios is a serious limitation. It has resulted due to a lack of training and dedicated staff. In addition, all the features provided in the high-fidelity simulators are not fully utilised to justify their cost. For simulation-based learning to be effective, the team comprising faculty/trainees from the concerned surgical specialities, technicians, nurses and anaesthesiologists should participate in the exercise together. For example, it may be prudent to perform a 'dress rehearsal' of a difficult airway case scenario a day before the scheduled surgery, with the entire team comprising surgeons, nurses, technicians and anaesthesiologists, who will be directly involved in managing the case. Hence, the line of command is established, roles are defined, and equipment and other logistics are arranged and tested one day before the dress rehearsal of the case.

Artificial intelligence (AI): AI and machine learning (ML) can be used in simulation to mimic real-life scenarios in operation theatres. ML is one of the branches of AI, wherein the computer must be fed with trillions of data to learn and predict the anticipated event or output.[2] The data of human physiological variables from the anaesthesia electronic recording system may be linked with ML, which can learn from multiple data points and make the simulation a tool to mimic real-life scenarios.[3] The most commonly used ML algorithms are supervised and unsupervised algorithms. The sequence of events during anaesthetic management with a high-fidelity simulator should automatically change the physiological parameters as per the actions of the participants instead of manual manipulation by the operator, which can be achieved with ML algorithms. Once the machine learns about the physiological or pathological consequences of the fed data, it starts responding to any action by the participants in a similar way as the human responds in real-life scenarios.

Future applications: Similar to the capsule endoscopic camera for the gut, a camera that provides a 360° view (drone capsule camera) instead of the existing end-on view may be designed for the flexible endoscope.[4] AI-acquired images of the glottis may be integrated with a drone capsule camera and night vision technology to help the operator identify and guide the tip of the flexible endoscope towards the glottic opening despite secretions and blood in the oropharyngeal cavity. Similarly, an AI application can be created to recognise and predict difficult airways. The patient's head and face can be assessed in different positions by integrating the face recognition application to provide a machine-assisted modified Mallampati score, range of neck movements, thyromental distance, mento–hyoid distance and other difficult airway predictors.

Three-dimensional (3D) printing and models: With the introduction of 3D models, which can be virtual and physical, the trainees can be taught about the anatomy of the tracheobronchial tree and its anaesthetic implications.[5] 3D reconstruction of the entire airway can be performed with computed tomography (CT) imaging in patients with difficult airways, compromised airways and those who require lung isolation. The management of patients with anticipated difficulty or compromised airways can be simulated with 3D reconstruction from the CT scan-acquired images. The most appropriate airway method to secure the airway may be planned with a high-fidelity dynamic breathing simulator before the procedure.

Virtual reality (VR) integration: VR can be integrated with 3D-reconstructed images of the airway images obtained by CT scan.[6] VR sets with controllers help to view the airway in multiple planes, mimicking the real-time endoscopy. This integration of VR with 3D reconstruction will be beneficial, especially in compromised airways where the lesions are in any part of the airway. Anaesthetic plans and plans for securing the airway can be planned meticulously with the dedicated software tool.

Amalgamation of simulation and AI: ML-integrated high-fidelity simulators can be utilised to plan for the optimal anaesthetic management of patients with complex diseases. Let us assume an obstetric woman with peripartum cardiomyopathy (PPCM) has been posted for lower segment caesarean section. The cardiac parameters, as evaluated by echocardiography, can be fed into the simulator. The patient's haemodynamic responses to various drugs likely to be used can be assessed before the planned surgical procedure. Such simulation-based learning exercises can help to plan and optimise perioperative care. Debriefing is an essential component of simulation-based teaching and learning. Debriefing (where the things are performed appropriately and where more improvements are required) is usually performed by the coordinator who runs the simulation scenario. If the machine provides the debriefing instead of humans, it would be more precise for the participants.

Thus, integrating ML and simulation in anaesthesia helps improve cognitive, psychomotor and affective domains in learners' teaching and training and helps in decision-making in patients with complex physiological derangements.

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