Cost-effective innovation of locally assembled mannequins for undergraduate skill development in parenteral drug administration

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Abstract:

INTRODUCTION: The new competency-based curriculum for undergraduate medical education by the Medical Council of India mandates simulation using mannequins for teaching parenteral drug administration. Traditional education tends to focus on textbook learning, whereas competency-based education concentrates on the outcomes that directly guide the assessment of learners.

OBJECTIVE: To introduce a module for the development of the core competency of parenteral drug administration using cost-effective locally assembled mannequins for hands-on skill development in administering injections to be assessed using objective structured practical examination (OSPE).

MATERIALS AND METHODS: Cost-effective and durable fiberglass arms from mannequins used for fashion display were prepared for parenteral drug administration. The padding is easily done with wadding and gauze/crepe bandages, and the assembling requires only 15 minutes per arm. The training can be conducted in the department, giving students adequate opportunity for hands-on learning on individual arms during the practical sessions. As initial investment and recurring costs are low, it is possible for the department to obtain enough number of mannequins for each student to practice individually on an injection arm.

RESULTS: Students practice injection technique freely, without fear of damaging the mannequin or having to do it on a patient. This helps them to assimilate the steps and sub-steps of doing the task in a much more realistic way and builds their confidence. Assessment of the performance of injection technique, infection control practices, and drug delivery are possible.

CONCLUSION: We have observed a greater trend toward self-learning and self-efficacy and better adherence to the protocol of injection technique because of the hands-on training the students receive.

Keywords: Cost-effective mannequins, injection, parenteral drug administration, performance-based assessment, simulation

Introduction

The main purpose of undergraduate medical education is to develop the requisite diagnostic and therapeutic skills of a basic doctor.[1] The traditional “apprentice model” of medical education, where learning took place by observation of more experienced colleagues is undergoing a

“pedagogical shift” to a simulation-based medical education where the earlier “see one, do one, teach one” is being replaced by “see one, practice many, do one.”[2]

One-third of all medication errors in patients occur in the drug preparation and administration phase.[3] A conscious human action can reach its intended goal if the steps and sub-steps of performing the task have been learnt and the skill mastered with
Errors arise when an intended action, such as intravenous administration of a drug, is inaccurately or inconsistently performed. Training medical students in safe parenteral drug administration is crucial to minimize medication errors, and students acquire better skills through hands-on performance on mannequins than merely watching them on video.\cite{5}

Lecture-based teaching is an effective educational tool in communicating knowledge but contributes little to experiential learning, and educators are often confronted by a theory-practice gap. Introducing mannequin-based simulation helps students to actually put the theory to practice and bridge this gap.\cite{6} Incorporation of simulation in medical training provides opportunity to develop new psychomotor and visual-spatial skillsets. It also promotes the student’s competence in performing the skill and instills confidence about his/her ability to perform the task.\cite{7} Miller defines competence as being “functionally adequate” and states that the student must know how to use the knowledge he has acquired. When assessing clinical competence, we must keep in mind that an individual moves from knowledge, through integrated knowledge to competence and finally performance (knows, knows how, shows how, and does).\cite{8} Simulations also offer a safe and realistic environment which helps to learn and practice the skills taught and experience mistakes without direct contact with a patient.\cite{9}

The transmission of blood-borne viruses and other microbial pathogens continues to occur because of the use of improper injection practices by health-care personnel.\cite{10} In the last 10 years alone, there have been at least 15 outbreaks of hepatitis B virus infection associated with health-care personnel failing to follow basic principles of infection control.\cite{11} The use of proper injection technique and infection control practices such as hand hygiene and aseptic precautions for injection of drugs can be readily incorporated into simulated teaching sessions with mannequins. To ensure safe medication preparation and administration, the students are encouraged to practice the “Seven rights” of medication administration: right patient, right drug, right dose, right time, right route, right reason, and right documentation.\cite{3}

With the release of the new competency-based curriculum for undergraduate medical education by the Medical Council of India (MCI), one of the two core competencies in experimental pharmacology is to “show” and “show how” to administer drugs through various routes in a simulated environment using mannequins.\cite{12} Traditional education tends to focus on the curriculum, whereas competency-based education concentrates on outcomes that directly guide the assessment of learners and explicitly require standards for these assessments.\cite{13} Salas et al. enumerate the principles by which simulation-based training can provide the opportunities for students to develop competencies.\cite{9} Having incorporated these principles in our mannequin-based simulated training module, we now have good modules to teach drug preparation and administration skills with student-friendly, valid and reliable objective structured practical examination (OSPE) stations for performance-based assessment of both psychomotor and affective domains of learning.

Although most medical colleges have “Skills-labs,” with expensive mannequins, simulated learning is not often integrated into the teaching of “routes of drug administration” for hands-on practice by students. With several studies demonstrating that students acquire better skills through hands-on performance on mannequins and with these cost-effective innovations for teaching parenteral administration of drugs, we have introduced this module in the undergraduate pharmacology practical sessions in our institution.\cite{3,6,14}

Materials and Methods

We evaluated that the cost of enabling each of our 100 students to effectively practice on commercially purchased mannequins would be massive and impractical and decided to look for alternatives. The readily available commercial mannequin models such as the injectable training arm models (XC-434) and electronic buttock injection simulator (XC431A)\cite{14} are expensive and need regular replacement if they are to be repeatedly used. Besides, providing individual practice sessions would require around thirty mannequins at one time. Skills laboratories in most institutions have one or two mannequins at the most because of the initial and recurring costs involved. The use of these mannequins is carefully monitored as the maintenance and upkeep of these models is expensive, technician-dependent, and time-consuming. We wanted student-friendly mannequins, resistant to multiple punctures, on which students can repeatedly practice administering drugs without restrictions and attain mastery. With this objective in mind, the faculty of the department of pharmacology set to work to develop a cost-effective injection arm mannequin model for skill development in parenteral drug administration for undergraduate students.

We procured thirty isolated arms from an agency (carbon mannequins) that supplies mannequins for fashion display for less than Rs. 1000/-each, far less than the cost of the XC-434 injection arm. We also obtained two whole mannequins for simulated training in intramuscular and subcutaneous injections at a cost of Rs. 6000/-each. This would make it possible for each
student to be able to practice on an individual arm at the same time during class. The total initial cost of getting thirty arms and two whole-body mannequins was less than the cost of one commercial mannequin model for drug administration that was purchased for our skills laboratory. The mannequin models we purchased are made of fiberglass as they are more durable. However, plastic mannequin model arms are also available at even less cost.

The arms were padded in the department for training students in intramuscular injection, intravenous injection, and cannula insertion with wadding. The procedure for the preparation of mannequins is outlined in Flowchart 1.

Procedure flowchart for preparation of mannequins
After research and trial on various packing and textile materials, we decided that using wadding and gauze, discarded from textile shops, was adequate to simulate human tissue. The flexible rubber tubing, routinely used in laboratories as tourniquets for venipuncture, was placed on the arm following the surface anatomy of the cephalic vein and covered with gauze/crepe bandage to simulate the fascia. The simulated veins were connected through used intravenous-set tubing to a reservoir containing red-colored fluid, to simulate circulation. The continuous flow of fluid in the tube allows the students to observe the flashback of fluid in the cannula/syringe at the entry of the needle into the vein and minimizes air bubbles/vacuum formation. The tubes can be easily flushed to ensure good flow. The whole arm was encased in a full arm glove, supplied by primus gloves agency at a minimal cost. As we piloted injection technique on these locally made injection arms and compared them with the commercial models, we found there was little difference. The photographs of the finished mannequin models are given in Figures 1-4.

The padding of the mannequin injection arms in the department was simple, not labor-intensive, and very cost-effective. The time required to prepare an arm was about 15 min. We have been able to use the arms without undue leakage or soiling for several sessions where students have repeatedly used them to practice intravenous injection, cannula insertion, and intramuscular and subcutaneous injections. After a series of sessions, the padded material can be removed and disposed, and the arms prepared with fresh padding for the next series of classes. Even though our weather is humid, we found the arms could be used for several sessions before they needed to be redone, as the flexible tubing allows multiple punctures with minimal leakage and soiling.

With the introduction of the competency-based curriculum by the National Medical Council for the MBBS education, it is essential to have a performance-based assessment of skills. We have standardized an assessment protocol for parenteral administration of drugs using OSPE which we have already effectively used in the pharmacology batches of 2016 and 2017. We have also completed a study on the perceptions of students regarding their skill learning and its assessment which is being prepared for publication.

Advantages of the locally assembled mannequins
• It is a cost-effective and realistic way in which pharmacology departments can comply with this requirement for experimental pharmacology of the new competency-based curriculum of the MCI (2018)[12]
• The training can be conducted in the department during the practical sessions without having to escort students to the skills laboratory
• Students have adequate opportunity for hands-on learning without the restrictions that are essential in a skills laboratory with few expensive mannequins
As initial investment and recurring costs are low, it is possible to obtain enough number of mannequins for each student to practice individually on an injection arm. Students do not hesitate to practice freely as there is minimal leakage or soiling even with multiple punctures of the simulated veins. The experience of performing the task helps them to assimilate the steps and substeps of doing the task in a much more realistic way, so that they can perform the task by simply following the protocol. Students perform successful injections, several times, without fear of damaging the mannequin or having to do it on a patient. This builds confidence. Valid and reliable OSPE is available to assess the student performance in injection technique, infection control practices, and drug preparation and delivery. As the opportunity is available, students develop a desire to hone their skills, and we have observed a greater trend toward self-learning and self-efficacy. In fact, we find students asking for extra time out of class hours for more practice.

We have received positive feedback from the students about these simulated sessions. Student perceptions and appraisal of their learning and the performance-based assessment will be published in another article. These sessions have enlivened the experimental pharmacology experience on routes of drug administration, and it has been a memorable experience for both faculty and the students.

**Discussion**

Conventionally, we have been teaching routes of administration in the pharmacology department, as a knowledge-based exercise with assessment mainly in the cognitive domain and teachers wonder if the student will be able to perform the task. There was no way of learning the techniques of parenteral administration (psychomotor domain) and how to communicate with the patient (affective domain) during the procedure except by watching a video. The availability of these low-cost mannequins makes it possible for repeated hands-on practice for skill development. As they are made aware of the steps of the task and the standards required for correct performance, the students not only “know how but also able to “show how” to perform an injection. We have also instituted a performance-based assessment of the skill using OSPE. The aim is to decrease the gap between knowledge and practice by giving opportunity for skill development during the practical classes in pharmacology on “routes of drug administration.”
Simulated learning does place the additional responsibility on the faculty to ensure the mannequins are properly set up. As our practical sessions in pharmacology are in the afternoon, we were able to set up the mannequins on the morning of the practical exercise with 25–30 students in each class. We also need to ensure the presence of adequate faculty to allow for troubleshooting during the class and classroom support personnel for various contingencies that may arise.

Giving students the opportunity to practice administering medications on a mannequin becomes a learner-centered and relevant learning experience. Experiential learning helps student to retain information using multiple senses while performing in the simulated environment with mannequins. Successful performance of the tasks boosts student confidence and prepares them to develop the poise and assurance they need to confront real patients in clinical settings.\(^\text{[6]}\)

Most medical colleges have a skills laboratory where injection techniques are demonstrated. However, the cost of these mannequins precludes repeated use, and so it is rarely integrated into their learning schedule. With the new curriculum in place, we have found our mannequin models are very cost-effective, and we can obtain an adequate number of mannequins to integrate skill development into our regular teaching schedule. Students find it a very effective way of developing their skill of administering injections and are grateful for the opportunity to practice injection techniques on these cost-effective injection arms as often as they like.

Conclusion

We have observed a greater trend toward self-learning and self-efficacy as students receive the opportunity to develop their skills. Aseptic precautions, sterile technique and infection control practices are practiced, performed and assessed. Students learn to adhere strictly to the protocol of injection technique as performance is assessed and we know that assessment directs learning.

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Conflicts of interest
There are no conflicts of interest.

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