International Research Journal of Medical Sciences _____ ISSN 2320 –7353
Vol. **1(10),** 1-6, November **(2013)** *Int. Res. J. Medical Sci.*

Training on Management of ENT Emergencies Using Low-Fidelity Nasal Simulator

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Available online at: www.isca.in, www.isca.me
Received 6th September 2013, revised 24th October 2013, accepted 25th November 2013

Abstract

Nasal Bleeding and Foreign bodies in the nasal cavity are common ENT (Ear, Nose and Throat) emergencies encountered in daily practice. Nasal bleeding (Epistaxis) is a serious health emergency which can lead to catastrophic consequences, if not controlled, especially in elderly patients or in remote localities. Nasal foreign bodies are associated with children and mentally ill people. Mishandling of foreign body may lead to its impaction or (suffocation) as it may be pushed further down and obstruct airway. Training of medical students on proper handling and management of these situations is crucial. The emergency nature of the problem limits training opportunities for the students on real subjects. Thislow fidelity simulator named (Soso-Noso)was invented to simulate the probable scenarios of nasal bleeding or foreign body in the nose. The simulator was introduced to the undergraduate medical students during their otolaryngology (ENT) internship to test its utility and effectiveness. The students took a pre-intervention test after learning the theoretical background of those conditions and its management. Then they were shown how to handle the simulator and students in small groups worked with it with minimal guidance of the lecturer. The simulator is equipped with a microcontroller and electronic proximity and contact sensors to detect the three different modes of treatment. Post-intervention test was done to measure the level of new acquired knowledge and confidence. Paired comparison of Pre- and Post-test scores (given out of 60) was done and Wilcoxon Signed Ranks test gave a significant difference ($p<0.001$). The mean scores were increased by 200% after working with Soso-Noso (i.e. from 14.6 to 45.73 with an increase of 31.13 marks scores). Written feedback from the students highlighted on gaining confidence in handling these cases as they become familiarized with different management scenarios using the simulator. Since Soso-Noso simulator is a light weight, low cost and user friendly device, its wider application in the teaching of ENT practices is strongly expected.

Keywords: Simulator, epistaxis, foreign body, low- cost, user friendly.

Introduction

Nasal bleeding (Epistaxis) is a frequent[1] and serious health emergency in Ear, Nose and Throat (ENT) specialty. Inappropriate assessment or wrong first aid management, may be life-threatening[2]in elderly patients especially in district areas. Another frequent problem in ENT practice is foreign bodies events[1]. It is encountered in children and mentally ill people. Mishandling of foreign body in nasal cavity may lead to (suffocation) as it may be pushed further down and obstruct airway.

Familiarizing the medical students with basic clinical skills is essential for ENT emergency practice and it is always mentioned in the medical curricula although the requirements cannot be fulfilled in all teaching centers[3]. A lot of factors limit the teaching of ENT clinical skills for the undergraduates. These factors include and not limited to short ENT posting[4] and limited exposure time to the outpatient clinics[5]. The emergency nature of ENT conditions frequently limits the medical students from attempting any clinical examination or investigation on those patients, let alone trying some hands-on experience of ENT procedures.

The medical faculties have realized those limitations of ENT trainings that efforts had been made to innovate alternative methods for training as in using simulators. Nowadays, simulators are widely used as effective tools to enhance skills training and cognitive learning. However, only few ENT simulators are currently available and they are still under development. Even though high technology simulators with high fidelity are more preferable, those gadgets will make the simulation an expensive tool in medical education[6]. The innovation of a low fidelity simulator with simple technology using easily available materials is to address these educational problems in a cost effective manner. A field testing with medical students was later done to assess the construct validity of the simulator. Since the purpose of this simulator was to familiarize the undergraduates with above mentioned emergency problems, the students' feedback as well as their academic achievements had been taken into consideration.

Material and Methods

A prototype, low-cost simulator has been developed with special emphasis on the basic skills required for controlling

epistax is and foreign body removal as shown in Figure-1. It is named SOSO-NOSO after "SOSO" as it is designed in life size of the human body. The suffix "Noso" comes from the term "the nasal cavity" and its spatial extensions as "nasopharynx" and "oropharynx" which are included in the model construction. It is not only noninvasive, but entirely free from the risk of infection, and provides an excellent low-tension learning opportunity. The fundamental design of the simulator is a PIC microcontroller[7] which responds to the different types of nasal packing. It is powered via DC adapter to avoid problems of run out of batteries. Two infra-red sensors were used to detect the proximity of objects during the nasal packing. Each sensor will trigger a signal and sends it to the microcontroller for processing based on the selected model[8,9]. The microcontroller will then illuminate a LED (Light Emitting Diode) to show the position of the nasal packing. Another sensor that is incorporated in the Soso-Noso is the electronic touch sensor which completes the circuit and triggers the microcontroller to show the success of the procedure[10].

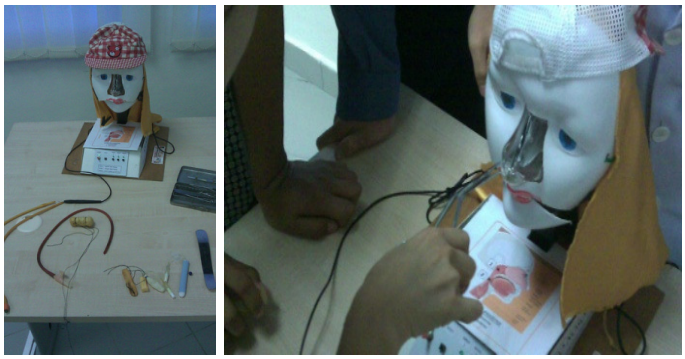

Figure-1
Using the simulator (SOSO-NOSO) in training session

Soso-Noso has a paradigm of three modes to simulate practical procedures to control epistaxis as shown in Figure-2. In mode 1, the trainee practices anterior nasal packing. For training purpose, control of nasal bleeding can be performed in 3 modes. In mode 1 and mode 2, both anterior and posterior nasal packing can be performed respectively. As an interactive device, when the candidate manages to perform it properly, the LED light will 'off'. Meanwhile if it is done wrongly, the LED will continue to be 'on'. In mode 3, local electrical cautery can be simulated. Failing to cauterize the appropriate site of bleeding, another alarming light will come on, to indicate more bleeding and failure of the attempt. Overall in the training exercise, the model allows low fidelity in management of 2 situations of nasal emergency. The simulator also provides an opportunity to try removing variety of foreign bodiesfrom the nose. As part of the training, the trainee needs to make a decision to choose the appropriate tools to solve the problem. The simulator provides opportunity for the trainee to commit error like choosing wrong tools or making wrong decisions. The complications of performing wrong procedures resulting in impaction or inhalation can be shown safelyinnon-threatening, low-tension situation.

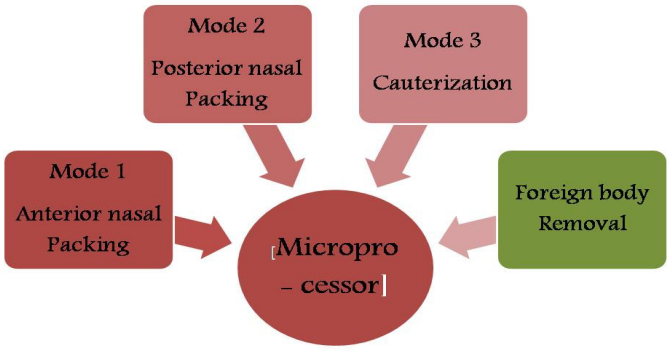

Figure-2
The simulator SOSO-NOSO is used to simulate 4 scenarios in nasal emergency

Design of the Study: This study is planned to assess the validity of the invented simulator to demonstrate the two ENT emergency conditions among undergraduate medical students. It is aimed to test its effectiveness in familiarization with the steps in controlling nasal bleeding (epistax is) and removing nasal foreign bodies. In this study, 30 students were chosen randomly to learn ENT emergencies with the help of the simulator. The students were made into two small groups of 15 students each. Prior to the simulator exercise, a formal lecture addressing on ENT emergency was given by a lecturer. The lecture was followed by a small group discussion guided by an instructor as it has been done routinely. A pre-intervention test [pre-test] questionnaire of 15 multiple choice questions was distributed to students to measure their level of knowledge prior to the simulator exercise. The intervention was done after the pre-test and students got hands–on training session with minimal interference from the faculty members. Students practiced different methods for managing (epistaxis) after a short demonstrate on by the lecturer on how to control nasal bleeding. The lecturer observed the learners and provided feedback to them. Similar exercise was done on managing foreign bodies in the nose. Different types of foreign body were removed using different tools and selection of tools was also part of the exercise. At the end, a post intervention test (post-test) questionnaire was distributed. The pre and post-test questions include basic knowledge on how to examine, investigate and manage the conditions. A question regarding students' confidence on managing nasal foreign bodies and nasal bleeding was included in both pre and post-test questionnaires.

Results and Discussion

The students involved in this educational study were randomly selected from the class of 4th year medical students studying in the School of Medicine. The students were formed in groups of 15 to minimize overcrowding during group discussions and clinical skills training. The grouping of students were done to ensure that each group has a fairly distributed mix of good, poor and average performers based upon their academic performance in previous years. Since the new method was exposed to the

students after a formal lecture presentation on ENT emergency, the pre-test scores gained by both groups showed above the baseline. However, the effect of this simulator aided learning was obvious after the hands-on training with gadget. The results showed that post-test scores were increased by 275% (i.e from 13.53 to 50.80 with an increase of 37.3 marks out of total 60 marks) and the difference was statistically significant with a *t value* of 20.469 and *p value* of less than 0.0001 as shown in table-1. Since a true zero point in the measurement scale of test scores could not be established, the authors felt that the application of parametric statistics might not be appropriate in this case. Thus a non-parametric test (Wilcoxon Sign Ranks Test) was also attempted to test the significance of difference between pre and post test scores. It also showed that the post-test scores are significantly higher with a *p value* of less than 0.001 as shown in table-2.

When item analysis for each question in the pre &post-test questionnaires was done, the students' achievement is highest in controlling nasal bleeding. In addition, this hands-on experience improve the students' confidence in managing ENT emergencies as they become familiarized with the handling of nasal bleeding by using this simulator.

Table-1
Paired sample test

Paired Samples Statistics					
		Mean	**N**	**Std. Deviation**	**SE Mean**
	Pretest scores	**13.53**	**30**	**6.976**	**1.274**
	Posttest scores	**50.80**	**30**	**9.312**	**1.700**

	Mean	**Std. Deviation**	**Std.Error Mean**	**t**	**df**	**Sig. (2-tailed)**
Pretest scores Posttest scores	-37.267	9.972	1.821	-20.469	29	<.0001

Table-2
Wilcoxon Signed Ranks Test

Ranks				
		N	**Mean Rank**	**Sum of Ranks**
Posttest scores - Pretest scores	**Negative Ranks**	**0[a]**	**.00**	**.00**
	Positive Ranks	**30[b]**	**15.50**	**465.00**
	Ties	**0[c]**		
	Total	**30**		
a. Posttest scores < Pretest scores		**Z = -4.785 P = <.0001**		
b. Posttest scores > Pretest scores				

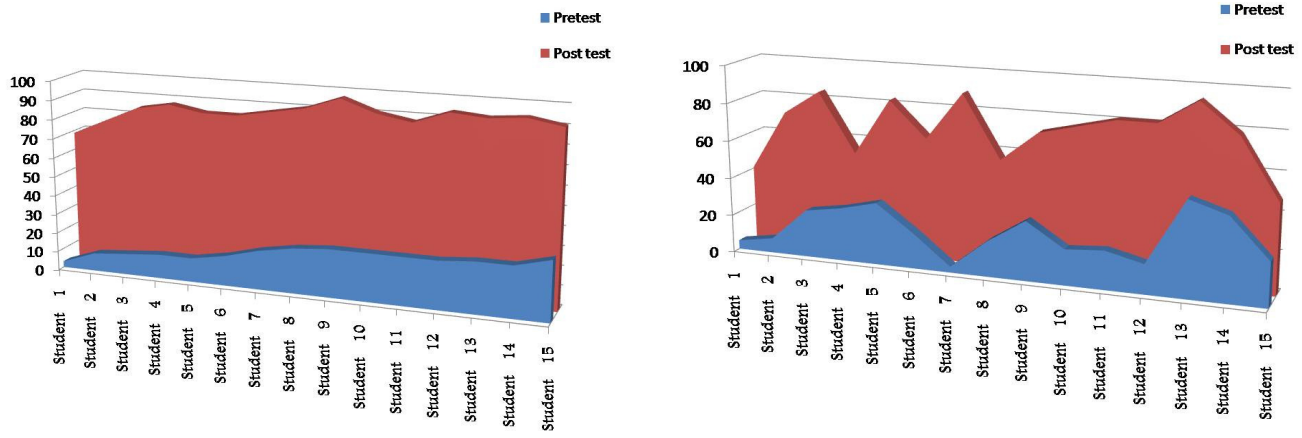

Figure-3
Pre- test and post test performance of participating students (Total n=30)
(Group 1 and group 2 on left and right hand respectively)

Discussion: Because of the close position of nose to the airway as well as critical neurologic and vascular structures, the nasal emergencies carry the potential for significant complications[11]. Acquiring clinical skills in managing nasal emergency is the clue to avoid any mishap. Unfortunately, there are many reasons contribute to the difficulty in acquiring clinical skills of managing this emergency. These are shown in Figure-4. Theshort time allocated for undergraduate ENT teaching and accordingly the acquisition of practical skills may suffer[4]. In spite of the positive impact of outpatient clinic rule in medical education, the student's exposure to outpatient clinics is less, particularly in emergency situations[5]. In spite of the students satisfaction in meeting real patient[4], face to face contact cannot be fulfilled in many teaching centers because of infeasibility with increasing number of medical students.The disproportion ratio between number of students and exposure to the patients led to a serious impact on students' learning of clinical skills[3]. Financial issues and complicated legal issues regarding patient's safety[12,13] are other factors that limit the live training of the candidates.

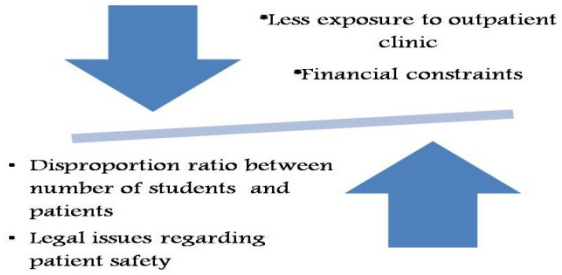

Figure-4
Factors contribute to the difficulty in acquiring clinical skills

Technology could potentially improve medical education, acquiring clinical skills and cost effectiveness[14]. Some modalities of technology in medical education are software based. Unified Patient Project (UPP) is an example for web-based blended learning is used in teaching ENT for medical students. Grasl et al stated that students' satisfaction with the (UPP) was lower than in traditional face to face teaching. However this was not statistically significant[15].Interaction with some medical simulations can be done with using the keyboard and mouse and the standard web browsers[16].

Simulation uses a simulator to imitate the operation of a system. The simulator should be developed first to represent the system itself. Simulation in teaching process, enables the learner to acquire new technical expertise by practicing Fitts and Posner theory of the three-stages of motor skill acquisition[12]. Three-stages of motor skill acquisition are cognition, integration, and automation respectively as shown in figure-5. Simulation is a flexible educational tools that improve technical skills. It also reduces the student's anxiety in facing real patient. Meanwhile, it is non–invasive technique which in favor of patient safety[12] as shown as in figure-6.

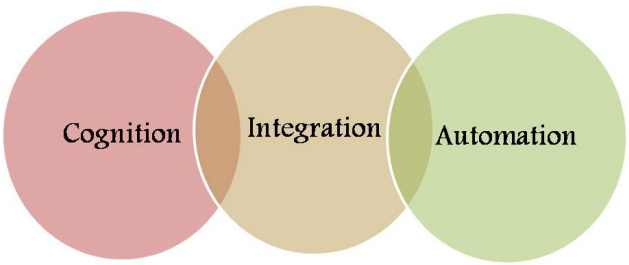

Figure-5
Motor skill acquisition is enhanced by using simulation

Simulation is a perfect teaching method in formal education institutes where there is direct contact between the academic staff and students. It plays a crucial rule in teaching process where specific curricula and text books are available[17]. It is also an effective method in health organizations as it increases the staff skills and refresh it. This increases the junior staff feeling of self-esteem and improves their performance[18,19]. The training in a non-stressful environment (Clinical Skill Laboratory) is suitable to learn about mistakes and pitfalls in performing procedures[13]. This increase the chances for the culture of the patient's safety[13].

The simulator is a perfect model that carries the characters which enables the operation to be presented[16]. The simulator becomes widely accepted, as long as it is relevant, affordable, and accessible teaching tool[20]. It is useful in training field, as it is used to teach medical concepts, decision making and to support training procedures. Medical simulators are designed in a way that model of the respective anatomy is connected to computer. Several simulators are full-body high-technology manikins adapted from other purposes.

Innovation of a medical simulator is a complicated process. A demand for a multidisciplinary team to design it. The medical personnel who comes with the scenario for consequence of events, mecha-tronic and software engineers who translate the scenario into a prototype[21]. At the end, the simulators are expensive tools. To overcome this obstacle many centers can share and exchange the expert personnel and resources[22].

Unfortunately, the perfect and sophisticated simulators are relatively expensive and are not affordable in many teaching institutes. In ENT specialty, simulators are used in both practical and educational fields. In practice, the surgeon uses 3-D simulator via computer software to enhance realism and to discuss with the patient the net outcome of the surgery. The inputs to these software are 3D CT or MRI of the patient data. They are reproduced by computer graphic techniques to deliver the final visual component of the simulation process.3D simulator helps the surgeon to study the defects and the alternative techniques for the procedure[23]. At the end,a virtual image of the patient's nose after rhinoplasty surgery is reproduced.

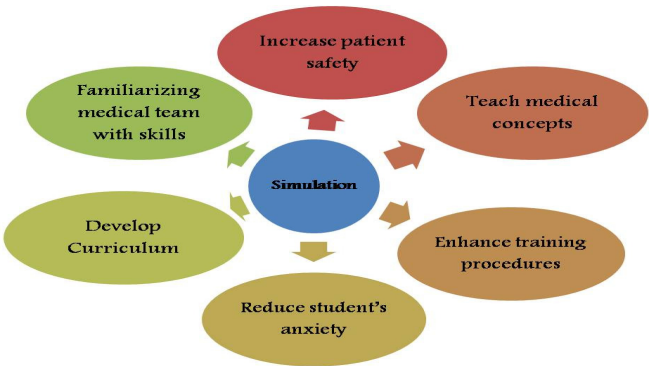

Figure-6
Advantages of simulation in medical training

Live simulations are sometimes called "high-fidelity", as opposed to "low-fidelity“ simulations which produce only “signs of possible performance”, “virtual” simulation where actual players use simulated systems in a synthetic environment[16] as shown in figure-7. Researchers and inventors try to develop variable types of simulators for both academic and practical purposes. According to Kremer et al, 10 sinus/rhinology simulators are documented. Most of them are virtual surgery simulators and prototypes. Few simulators are electrical, for learning non-technical and teamwork skills[6]. Soso-Noso was invented to be a non sophisticated simulator, designed in convenient technology. It is built with a lightweight plastic, portable model, easily used anywhere. The spatial orientation of the nose and related structures become more comprehend. This is a simple, low-cost construction and easily maintained. It works independently without connection to internet or attached to computers. This addresses both technical and financial issues in the education process[14]. Shank et al suggested that value simulator-based procedural teaching in the form of small-group sessions. In teaching with simulation, the instructors demonstrate techniques, and allow the students to do it themselves, observe learners and then provide feedback to learners[12].

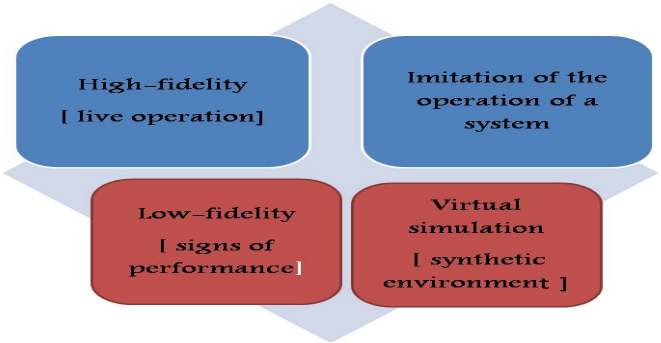

Figure-7
Levels of simulation in medical training

In our experiment, the instructor demonstrated the procedure and allowed some of them to practice it. The different types of nasal packing were handled and used. In the paradigm for removing foreign bodies, different tools were used freely. There was a room for the student to conclude which instrument was appropriate. Meanwhile the instructor had the chance to explain the merits of each tool in a feasible example. This hands-on training had been reflected positively on student's cognitive outcome. The post test scores were increased by 200% (i.e from 14.6 to 45.73 with an increase of 31.13 marks scores) and the difference was statistically significant ($p<0.0001$). The students enjoyed practicing the procedure on their own. Meanwhile they requested longer time to practice individually. There was a safe chance to try the concept of cauterization for bleeding point with no fear or harm to the patient. Wilcoxon Signed Ranks test showed a significant difference with $p<0.001$.

Simulation sessions should be an integral part of the teaching methods in medical institutes[12]. There is a need to develop an advanced medical training course which has been modified to include several stages: evaluation of the qualification of students; lectures, seminars and practical lessons. This helps ENT doctors to be better prepared when coping with urgent cases, which in turn leads to lower lethality rate and more successful rehabilitation of patients[3]. Currently, Soso-Noso simulator is used in teaching ENT for undergraduates in our school. The school planned to extend medical teaching via simulation. A new simulation laboratory is available for teaching medical emergencies.

It is hoped that continued familiarization with these' disease processes will maintain them as rare entities of medical practice[11]. Also it will allow proper management and referral, which can reduce potential lethal incidents[2,3]. However in spite of the limitations, the study showed short term improvement in the cognitive outcome. So far, long term assessment is yet to be done. As a prototype model, a room for improvement in term of fine tuning, shaping and higher fidelity can be achieved in the near future.

Conclusion

Soso-Noso is user friendly, low cost and light weighted simulator. It can be used in a large scale in explaining the first aid and possible procedures may increase awareness among medical students, general physicians, nursing and paramedic staff. Materials and structural modifications are in progress to use this model to train more skills. Simulation is a supporting tool for the advanced training curriculum. Training on critical skills will enhance the management of potential lethal incidents. The experimental result of using this Soso-Noso shows significant improvements in the understanding of the subject matter and an improvement in practical confidents of the medical students. The pre-test and the post test conducted shows the mean scores were increased by 200% after working with Soso-Noso and Wilcoxon Signed Ranks test to test the significance of difference between pre and post test scores gave a significant difference ($p<0.001$).

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