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COMMENTARY

Man-O-War simulator: a Low-cost manikin for training on chest tube management

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ABSTRACT

Simulation-based medical education is becoming a cornerstone in health education. Simulators are commonly expensive and not available in developing countries.

We propose a very low-cost simulator that any educator can realize. We describe here the steps to follow to develop this proposed simulator.

Background

Medical education has undergone significant changes all over the world. The introduction of novel technologies has revolutionized progress in this field.

The acquisition of appropriate clinical skills is a cornerstone of health education. However, in old traditional 'didactic' medical teaching, students sometimes complete their educational programs armed with theoretical knowledge but lack many of the clinical skills vital for their work [1].

Simulation-based medical education is defined as any educational activity that utilizes simulation aides to replicate clinical scenarios. It is becoming an effective method of teaching in the health area, with large widespread. Several factors have led to the introduction of simulation and the development of simulation centers and clinical skills laboratories in medical education: Concerns about patient safety, fewer available patients for learning, and many other factors have led [2].

Simulation provides many benefits: it improves trainers' psychomotor skills and guarantees the patient's safety, reducing medical errors and health costs. Simulation offers opportunities to practice with no risk to a patient; it facilitates learning through immersion ('immersed into the clinical scenario'), reflection, feedback, and practice minus the risks inherent in a similar real-life experience [3].

Fidelity is the common industry term used in simulation to describe 'the degree to which the simulator replicates reality. This is dictated by the needs of the application; the more complex the task; the more fidelity of the model is needed.

Using this definition, simulators are labeled as either 'low' or 'high' fidelity depending on how closely they represent 'real life. Fidelity is closely linked to costs and may represent a limitation to training by simulation. Oppositely, low-fidelity models can be developed and updated rapidly [4].

One of the major complex skills that junior physicians have to achieve, namely in emergencies, is chest tube management. This is a psychomotor technical skill that requires manual skill and experience, and thus, needs practice [5]. Besides, the risk of complications with this procedure (such as bleeding, and vascular and solid organ injuries) is high among inexperienced physicians [6].

We describe how we have made a do-it-yourself chest tube simulator.

Methods

1 We bought a funnel-shaped bucket with these dimensions: upper diameter 20 cm, lower diameter 35 cm, and length 30 cm.
2 With a permanent marker, we drew a rib cage on the bucket, with a sternum in the middle and five pairs of ribs laterally on both sides. Ribs were 2 cm large and 10 to 15 cm in length. Intercoastal spaces were also 2 cm large.
3 Using a straight grinder machine, we cut the plastic between ribs to individualize the intercostal spaces. Thus, we obtained a form like a rib cage that comprises ribs anchored to the sternum.
4 Then, a plaster casting roll was cut into 4 cm strips, lengthwise. These strips were wrapped around ribs. We flatten the applied plaster with our fingers as we wrap and we ensured that each new pass

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Fig. 1. The simulator structure allows to the learner to palpate ribs and to identify intercostal spaces.

of the plaster overlaps the one before it. Ribs become stiff, with 1 cm width, and offer a real sensation of bones on palpation.

5 Afterwards, cellophane paper was rolled around the bucket.
6 We Placed gaffer tape along the intercostal spaces and molded it well over the spaces. This assembly mimics the parietal pleura.
7 Next, to represent the parietal wall, we anchored a special type of foam mattress “extra dur” on the bucket with screws and nuts. This type of foam was purchased from the factory. Dimensions were 60 cm in length, 30 cm in width, and 5 cm in thickness. This type of foam had a similar density to flesh and offers a real feeling when palpating and introducing a drain.
8 After all, the bucket was fixed to a basin filled with 5 kg of melted white cement. This basin acts as a support.

In practical use, this model allows learners to: palpate ribs and identify intercostal spaces, perform a syringe puncture and apply local anesthesia, realize the initial skin incision, bluntly dissect the chest wall, puncture the pleura, insert the chest tube into the desired location, and to suture the chest wall (Figs. 1, 2, 3).

Once tube insertion is complete, the model can be taken apart to determine the exact tube placement.

The chest wall could be punctured in all spaces until there are too many cuts to reuse it, at which time a new chest wall is placed.

With a maximum of 3 essays in each intercostal space, this chest wall offers at least 30 essays.

This model takes approximately 1 hour to initial construction and 15 min to replace the parietal pleura and parietal wall.

We recorded a video to demonstrate the construction and assembly of this model in detail Table 1.

Fig. 2. A photography showing how the simulator allows the learners to perform a syringe puncture and apply local anesthesia.

Table 1
List of supplies and associated costs used.

List of Materials	Costs in Dollar ($)
Bucket	3
Plaster casting roll	2.5
Cellophane paper	1.5
Gaffer tape	2
Foam mattress	2.5
Basin with 5 kg of white cement and nut screws	3.5
Total cost	15

Discussion

The use of sheep rib hemithorax for the training of chest drain insertion technique is the commonly used method in the Trauma course organized in Tunisia. The main advantage of this method is its low cost and easy availability of the material. However, it presents several limi-

Fig. 3. a photography showing how to realize the initial skin incision, bluntly dissect the chest wall, puncture the pleura, insert the chest tube into the desired location, and to suture the chest wall using the simulator.

tations: it needs logistic organization to preserve the material, especially cooling care. In addition, it is a low-fidelity model and does not reproduce the real conditions to accurately acquire the technique.

Other more sophisticated models were developed. Bettega et al developed, in partnership with the technological university, a simulator using 3D printing of the bony framework of a human thorax, using chest tomography [3]. This simulator had a cost of 133 dollars and was shown to be equivalent to the animal model in the simulation for practical learning. However, this model requires advanced technology (3D impression) that is still expensive, requires skilled users for operation, is slow for mass production, consumes a lot of energy for operation, and is not yet widespread.

Tatli et al [7] have developed a simulator model by modifying the display mannequin obtained from a clothing store supplier for $40. They then constructed "ribs" and "intercostal spaces" by drawing and then drilling outlines where the 3rd, 4th, 5th, and 6th ribs should be on the right side of the thoracic region. This resulted in the construction of "ribs" and "intercostal spaces" on the mannequin. Small holes for screws to attach the chicken meat around these ribs were performed. They then prepared 3 sections of 10-cm packaging tape, for $2. These sections were inserted from the lower part of the mannequin to simulate the pleura, and were attached to the interior of the "ribs" and the "intercostal spaces". The chicken breast was used to simulate cutaneous and subcutaneous tissues. One piece of chicken skin and breast was needed for each 5 to 6 procedures, at a cost of approximately $5. Thus, the simulation model was made ready for use. The total cost of this model was $50, and the total preparation time was approximately 60 min.

Young et al from California [8] constructed an anatomically-detailed model using a Halloween skeleton thorax, dress form torso, and a yoga mat. The total cost was $198.

Current high-fidelity simulation models that allow chest tube placement are some of the most expensive on the market, compared to further procedural simulators. Their cost are ranging from thousands to tens of thousands dollars [9,10].

Regarding its low cost (15 $) and easy production technique, our simulator represents a particular value in Low and Middle Income Countries, such as African countries. This model could be self-produced by educators in these countries and offer trainers the opportunity to perform their competence and self-confidence. We used this simulator for the first time to train 80 Emergency doctors during the 22th congress of the Tunisian Emergency Medicine Society (STMU) on May 2022. All the trainees practiced the insertion of chest tube at least twice and were satisfied by this experience. Satisfactory survey will be published soon. We also encourage further studies on this new simulator.

Dissemination of results

This simulator has been tried in a workshop during the national congress of emergency medicine among 74 participants.

Authors' contribution

Authors contributed as follow to the conception or design of the work, the acquisition, analysis, or interpretation of data for the work; and drafting the work or revising it critically for important intellectual content: AN 50%; OCW 30%; MN, AS, AT, HK, HS, IR, RK, and NR 2.5% each. All authors approved the version to be published and agreed to be accountable for all aspects of the work.

Declaration of Competing Interest

The authors declared no conflicts of interest.

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