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Rubber arm with fluid system for venipuncture training, new model in clinical skills tutors

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Abstract

The newly developed artificial arm allows puncture practice with an arm model that has similar touch to human arms, providing effective training environment for blood drawing. The rubber arm (RA) with a fluid system for venipuncture which duplicates the 3 veins of the human arm as closely as innovative technology allows. The venous system simplifies setup with only one internal fluid box and pump supplying artificial blood to all veins simultaneously. The antecubital fossa includes the median cephalic, median basilic, and median cubital veins in the rubber arm. The Rubber arm with fluid system was developed by integrating five-degrees. Subjective responses such as perception of the RA and perceived fall were measured by questionnaires. Experiment 1 shows strong agreement and agreement in virtual arm (94%) sized (93%) and color (63%). In experiment 2, 99.9 % were able to perfect the technique of venipuncture; to draw blood from veins. This research investigated the possibility of the rubber arm fluid system using matched or mismatched

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medical science students of venipuncture training . It can help with confidence and understanding the steps in the first draw after using this model.

Keywords: Rubber Arm, Venipuncture, Fluid System, Medical science student

1. Introduction

The rubber arm fluid system for venipuncture is in use in training for students of medical technology programs who pursue clinical assistance which may have to draw blood, known as phlebotomy, as part of their duties [1]. Phlebotomy is the task of placing a needle inside a vein (venipuncture) or capillary in order to collect blood. Medical assistants learn this skill as part of their clinical training in medical assistant school. It will provide high quality blood samples without causing discomfort to the patient [2].

Venipuncture has been reported as the leading cause of injury to both patients (1.2 to 2 million injuries per year 3) and practitioners (400,000 to 1 million injuries per year 4, 5) in the U.S. [3]. Repeated failure to start an intravenous line has been shown to significantly increase the chance of tissue damage and blood borne disease transmission, and may necessitate alternative pathways of much greater cost and risk [4]. This data shows that failed venipuncture is estimated to have a high cost. The problems associated with venipuncture have driven the development of numerous commercial technologies to assist clinicians in finding veins [5].

The rubber arm duplicates human arm conditions as closely as modern technology allows [6]. This unit is the simulation of the entire human arm from the shoulder to the fingertips. Externally, the skin texture is realistic to touch and consist of finger tips. The advance skin is prolonged by utilizing smaller needle sizes, such as 20- to 25-gauge. However, it cannot see the repeated position of inserting the needle.

The venous system simplifies setup with only one internal fluid box and pump supplying artificial blood to all 3 veins simultaneously to pass through the system until air bubbles have been eliminated. It has good understanding of the veins and associated nerves within the arm [7]. The superficial veins of the arm are usually chosen for venipuncture, namely basilic, cephalic and median cubital veins in the antecubital fossa [8]. These veins are recommended as they are well supported by muscles and connective tissue, visible and easy to palpate. Palpation is also an important assessment technique which determines the location and condition of the veins, distinguishes veins from arteries and tendons and identifies the presence of valves [9]. Venipuncture techniques correctly identified all types of patients and safely obtain high-quality blood specimens from them [2].

The present work provides the evaluation of the rubber arm with fluid system for training of drawing blood. The production cost is cheaper than other training arms. The technology described in this paper has the potential to improve medical science efficiency and safety, increase workflow, and reduce costs due to consumables. The technology can be furthermore extended for model robotics access in the future.

1.1 System design

A Rubber arm

The rubber arm features a flexible wrist for improved realism. It has a closed blood system including the median cephalic, median basilic, and median cubital veins which is cleaner to use. The self-sealing material used for the veins, as well as the skin is specially molded for improved feel, durability and palpation of the veins.

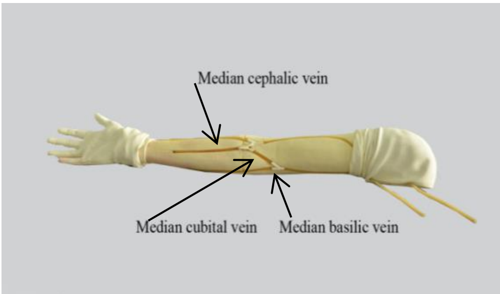

Fig. 1 The arm without the skin

Fig. 1 shows the arm without the skin. Internally the vascular structure (dry natural rubber tubing) includes the basilic, median, and cephalic veins. This venous system is constructed of special self-healing dry natural rubber tubing, with the lumen being the approximate size of a human vein. This vascular structure has an inlet tubing and outlet tubing at the shoulder, and it is via these tubes that the venous system is filled. Thus, the techniques of blood drawing and starting intravenous infusions may be practiced on the rubber arm and fluid system.

1.2 Pressure the system

A fluid system is a continuous vein system and innovative one bottle sealed blood assembly. The pump contains a controller which continues to run the electric motor until blood flows through the arm. Periodically the pump can be adjusted to maintain the pressure in the system during use.

Fig. 2 Fluid system for venipuncture arm

1.3 Venipuncture Arm

Venipuncture arm trainer has been improved and now has more pronounced veins in the antecubital fossa region of the forearm. With an extremely realistic finish, it shows a well-developed male left arm in fine detail. The arm features a flexible wrist for added realism, durable latex skin and it is simple to setup, operate and maintain. Venipuncture can also be performed along the basilic, cephalic, and median veins. Valves in the veins can be seen and palpated on the skin surface. Simulated veins and skin are completely replaceable to keep this training arm looking and working like new.

Fig. 3 Innovation of rubber arm with fluid system

2. Objective

This paper presents the findings of a questionnaire survey which aimed to evaluate the rubber arm with fluid system for training of drawing blood.

3. Materials and methods

3.1 Participants. 84 participants recruited from students who register in basic techniques for medical technology at Rangsit University, participated in the experiments. All participants received a detailed explanation of venipuncture techniques.

3.2 Experimental design. The questionnaires were adapted from a previous study investigating perceptual experiences during the traditional rubber arm illusion. Denying 5 possible perceptual effects using a 5-point visual analogue scale ranging from 1 to 5. The participants were informed that 1 means ‘‘Strongly Disagree’’ and 5, ‘‘Strongly Agree’’. Experiments 1 and 2 were designed almost identically except that in experiment 1, the participants saw the rubber arm in a synchronized and colorized manner as it was applied to the real hand (visual expectation conditioning), whereas in experiment 2, they received no visual feedback at all (no visual expectation), meaning that they did not know the steps for venipuncture. Thus, the participants were practicing venipuncture.

3.3. Procedures

3.3.1. Rubber arm. The participants were trained on the rubber arm. They were not allowed to move pending training for previous persons or employability skills. Performance of safe and efficient work practices in obtaining adequate and correct blood specimens by venipuncture on adults and children. The rubber arm will cover safe techniques and principles for assessment and selection of veins suitable for venipuncture. Venipuncture skills were delineated on the basis of lecture images observed in every frame.

Delineation of the venipuncture steps [4]

1. Wash your hands again and put on disposable gloves.

2. Insert the needle into the syringe. Move the plunger within the barrel to check movement.

3. Apply the tourniquet. Wrap it around the patient’s upper arm 3 to 4 inches above the antecubital fossa (cross the ends of the tourniquet and pull them snugly against the patient’s arm). With your thumb and forefinger, hold the tourniquet in place while pulling a loop of one end behind the joined area.

4. Select the venipuncture site.

5. Ask the patient to make a fist.

6. Palpate the antecubital area with your index finger to determine the exact vein location and needle entry site.

7. Clean the antecubital area (or other selected site) with an antiseptic or alcohol wipe needle.

8. To perform venipuncture:

- Make sure the patient's arm is in a downward position to prevent reflux or backflow.

- Use your thumb to draw the skin taut to anchor the vein.

- Line the needle bevel up with the vein.

- With a single, direct puncture, enter the vein at a 15- to 30 degree angle.

- Observe for a "flash" of blood in the hub of the syringe.

- Have the patient release his or her fist.

9. Slowly pull back the plunger of the syringe. Be certain that you do not move the needle after entering the vein. Fill the barrel to the needed volume.

10. Release the tourniquet when you have obtained the appropriate volume and venipuncture is complete.

11. Immediately place a sterile gauze pad over the site and withdraw the needle from the patient's arm.

12. Apply pressure or instruct the patient to apply pressure on the puncture site with sterile gauze.

13. Transfer the blood immediately to the required tube(s) using the syringe adaptor. Invert the tubes after the addition of the blood.

14. Discard the syringe in an approved container.

15. Use the preprinted labels or label each tube with the patient's first and last name, identification number (if applicable), date and time of collection, and your initials.

16. Check the venipuncture site to make sure bleeding has stopped, and then bandage it.

17. Remove and dispose the gloves.

18. Evaluate the patient for signs of faintness or color loss.

19. Complete the laboratory requisition form and route the specimen to the proper place.

3.3.2. Rubber Arm with fluid system Questionnaire.

After finishing each experiment the participants reported their perception of the rubber arm and fluid system using the Perception Scale, which includes eleven questions. The participants were also required to give detailed answers to an open-end questionnaire asking about their experiences and changes in their perception during the experiment in Table 1.

3.4. Data Analysis.

All values are expressed as mean standard error.

4. Results

Considering the percentage of respondents who agree and strongly agree on, the result as follows:

Results of experiment 1: Evaluation of the rubber arm uses a graphical representation the percentage of the answers and looks for differences in response patterns with respect to personal criteria. The rubber arm was 94% similar to the real arm, 92 % in terms of shape, 63% of skin tone, and 77% of real vein. The first four questions (Q1–Q4) were designed to correspond to the rubber arm illusion.

Results of experiment 2: Evaluation of using models show 94% comfort ability of drawing blood from the model and 92.8% a virtual sampling. Therefore, rubber arms are 95.2 % useful to practice first before actual arms. Rubber arms are used 94% in the classroom to prepare the blood draw and 99% of process of venipuncture training. Finally, they have 89% confidence and 97.6% satisfaction in the blood draw.

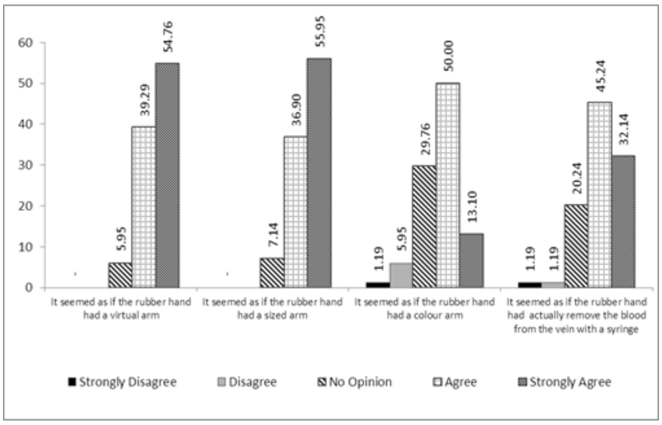

Fig. 4 Questionnaire data showing the percentage of the evaluation of rubber arm and ratings on a 5-point scale.

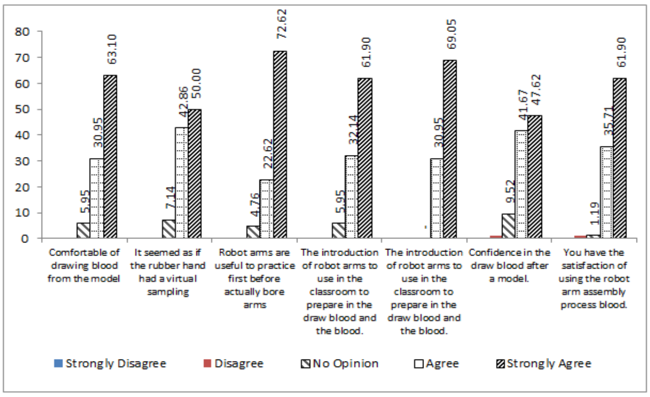

Fig. 5 Questionnaire data showing the percentage of the evaluation of using rubber arm and ratings on a 5-point scale.

5. Discussion

In this research, rubber arm with fluid system can perform simulation of venipuncture training. The median cubital and cephalic veins are most commonly used for venipuncture [4]. The position of the draw site for best visualization and/or palpation shows 77 % as the real vein. The rubber arm displays size and color as virtual arm for comfortable blood drawing from the model. There are many steps of venipuncture which should be memorized such as selection of the proper size needle and attach it to the syringe or vacutainer hub [10]. They pull the plunger in and out to assure free motion when using a syringe [11]. Rubber arm with fluid system shows 94% to prepare for the blood draw. They can practice to insert the needle through the skin, bevel side up, at a 15 – 30 degree angle with the skin, into the lumen of the vein [4]. Rubber arms with fluid system are 95% useful to practice first before real arm. This step should remind of patient complains of “shooting, electric-like pain, or tingling or numbness proximal or distal to the puncture site,” the needle should be removed immediately. It is possible that a nerve has been punctured and possibly damaged [12]. Apply the tourniquet should not loosen the tourniquet, as it may be obstructing blood flow [13]. Sometimes attempted to reposition the needle and are still not successful. It should remove the tourniquet, remove the needle and begin the process with a new site. Finally, when the collection of the blood is complete, remove the tourniquet and place gauze over the venipuncture site. While the needle is still in the vein, activate the safety button with the tip of the index finger; the needle will automatically retract from the vein and the safety device will cover the needle. Apply adequate pressure to the puncture site to stop the bleeding and avoid formation of a hematoma [12]. Do not have the rubber arm bend his/her arm; this may cause the arm to start bleeding when the arm is straightened out [4]. Blood was drawn with a syringe, attach the blood transfer device to the syringe and fill tubes according to the ‘Order of Draw for a Venipuncture’[4]. Rubber arm with fluid system is 99.9% similar to the blood drawing process from a real arm. Therefore, dispose of the contaminated materials and needle in the appropriate waste containers. Mix and label all appropriate tubes at the patient’s bedside [14]. Rubber arm with fluid system shows 92.8 % virtual sampling. Even though rubber arm with fluid system showed better accuracy, the practical difference and effect size were not large. Furthermore , it has been agreed that the rubber arm with fluid system has been given 89.2% confidence and 97.6 % satisfaction.

6. Conclusion

Our focus in this study was to determine how responsive rubber arm with fluid system would be specifically in venipuncture training. Experiments were made on a real arm and using venipuncture training. It is important to remember that medical technologies are trained to perform venipuncture procedures. Nowadays, there are several advanced venipuncture arms in market’s abroad. They are imported from foreign countries with higher cost, more complexity and more difficult to repair and maintain. The researcher tried to produce new innovation for venipuncture arm to develop venipuncture training.

7. References

[1] N. J. Jebbin and J. M. Adotey, "An audit of basic practical skills acquisition of final year medical students in a Nigerian medical school," *Ann. Afr. Med.*, vol. 11, no. 1, pp. 42–45, Mar. 2012.

[2] G. Lima-Oliveira, G. Lippi, G. L. Salvagno, M. D. R. Campelo, K. S. A. Tajra, F. dos Santos Gomes, C. D. Valentim, S. J. C. Romano, G. Picheth, and G. C. Guidi, "A new device to relieve venipuncture pain can affect haematology test results," *Blood Transfus. Trasfus. Sangue*, vol. 12 Suppl 1, pp. s6–10, Jan. 2014.

[3] A. Chen, K. Nikitczuk, J. Nikitczuk, T. Maguire, and M. Yarmush, "Portable robot for autonomous venipuncture using 3D near infrared image guidance," *Technology*, vol. 1, no. 1, pp. 72–87, Sep. 2013.

[4] *WHO Guidelines on Drawing Blood: Best Practices in Phlebotomy*. Geneva: World Health Organization, 2010.

[5] C. A. Troianos, G. S. Hartman, K. E. Glas, N. J. Skubas, R. T. Eberhardt, J. D. Walker, S. T. Reeves, and Councils on Intraoperative Echocardiography and Vascular Ultrasound of the American Society of Echocardiography, "Guidelines for performing ultrasound guided vascular cannulation: recommendations of the American Society of Echocardiography and the Society of Cardiovascular Anesthesiologists," *J. Am. Soc. Echocardiogr. Off. Publ. Am. Soc. Echocardiogr.*, vol. 24, no. 12, pp. 1291–1318, Dec. 2011.

[6] NASCO, "Injectable training arm LF00698 instruction manual," 2001. [Online]. Available: http://www.worldpoint.com/PageFiles/132/Instructional%20Manuals/IV%20and%20Injection%20Simulators/IV698_Venipuncture%20and%20Injection%20Training%20Arm.pdf. [Accessed: 17-Jan-2016].

[7] K. H. Kim, E. J. Byun, and E. H. Oh, "Ultrasonographic findings of superficial radial nerve and cephalic vein," *Ann. Rehabil. Med.*, vol. 38, no. 1, pp. 52–56, Feb. 2014.

[8] G. Lippi, P. Avanzini, R. Aloe, and G. Cervellin, "Blood collection from intravenous lines: is one drawing site better than others?," *Lab. Med.*, vol. 45, no. 2, pp. 172–175, 2014.

[9] M. Ichimura, S. Sasaki, M. Mori, and T. Ogino, "Tapping but not massage enhances vasodilation and improves venous palpation of cutaneous veins," *Acta Med. Okayama*, vol. 69, no. 2, pp. 79–85, 2015.

[10] C. Fujii, “Clarification of the characteristics of needle-tip movement during vacuum venipuncture to improve safety,” *Vasc. Health Risk Manag.*, vol. 9, pp. 381–390, 2013.

[11] K. Jaschke, D. Brown, A. Clark, S. Doull, A. English, N. Hoover, P. Jones, D. Klamm, C. Odom, B. Primrose, K. Sollars, and M. Ebberts, “Speed of blood withdrawal and accurate measurement of oxygen content in mixed venous blood,” *Am. J. Crit. Care Off. Publ. Am. Assoc. Crit.-Care Nurses*, vol. 23, no. 6, pp. 486–493, Nov. 2014.

[12] D. Milutinović, I. Andrijević, M. Ličina, and L. Andrijević, “Confidence level in venipuncture and knowledge on causes of in vitro hemolysis among healthcare professionals,” *Biochem. Medica*, vol. 25, no. 3, pp. 401–409, 2015.

[13] S. Sasaki, N. Murakami, Y. Matsumura, M. Ichimura, and M. Mori, “Relationship between tourniquet pressure and a cross-section area of superficial vein of forearm,” *Acta Med. Okayama*, vol. 66, no. 1, pp. 67–71, 2012.

[14] A. P. Morrison, M. J. Tanasijevic, E. M. Goonan, M. M. Lobo, M. M. Bates, S. R. Lipsitz, D. W. Bates, and S. E. F. Melanson, “Reduction in specimen labeling errors after implementation of a positive patient identification system in phlebotomy,” *Am. J. Clin. Pathol.*, vol. 133, no. 6, pp. 870–877, Jun. 2010.