Development of Simulation Model for Transradial Catheterization Practice for Physicians

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ABSTRACT

Objective: This study tested different types of silicone rubber material to assess the most durable with properties that best simulated the human skin and vascular. The optimal materials were used to produce a transradial catheterization simulation model to train medical practitioners and tested the improvement of the training with a medical simulation model.

Materials and Methods: Three types of silicone rubber were tested for their suitability as artificial skin and vascular for transradial catheterization simulation model. Eighteen fellowship physicians assessed the simulator's operational effectiveness and recorded their satisfaction with the training.

Results: Silicone rubbers were tested for realism and capability for repetitive training. Silicone rubber RTV-01 was the most durable for simulating the artificial skin, while silicone rubber RTV-03 was the most durable for simulating the artificial vascular with statistically significant results recorded by Kaplan-Meier analysis ($P < 0.1$). Satisfaction assessment results of the 18 participants using a Likert scale (5 points) returned total average scores of model's efficacies as 4.41 and total average scores of model's usefulness as 4.59.

Conclusion: The materials were used for transradial catheterization simulation to enhance fellowship trainees' learning efficiency through practice. The fellowship trainees became familiar with the equipment, gained a higher completion rate, and increased confidence in treatment planning.

Keywords: Transradial catheterization; medical simulation model; silicone rubber (Siriraj Med J 2022; 74: 570-574)

INTRODUCTION

Coronary artery disease (CAD) or ischemic heart disease (IHD) is the leading annual cause of death worldwide.[1] Coronary angiography (CAG) is the gold standard procedure used to diagnose blocked areas in coronary arteries. Vascular access for coronary angiography can be performed via the femoral artery at the groin or via the radial artery at the wrist. A transradial catheterization procedure is safer than a femoral artery approach. The patient recovers faster, with a reduced risk of complications after the procedure[2-4]; however, vascular system access via the radial artery requires skillful catheter insertion into a smaller vessel than the femoral artery.

Currently, diagnostic cardiac catheter training is performed directly on patients under the supervision of a senior fellowship or staff physician. The Siriraj Hospital Faculty of Medicine has modernized instruction methods that now promote outcome-based education[5], with learning and teaching styles focusing more on treatment outcomes. Practical approaches are now encouraged to supplement

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lectures.[6] However, patient numbers are often insufficient to allow students adequate medical practice for many of the procedures, and as a result, some students lack confidence when treating patients. Practicing simulation techniques allows the students to gain experience before performing in real operation settings. Simulated training methods improve confidence and proficiency, allowing detailed preparation of each treatment step.[7-15] Due to the recent coronavirus COVID-19 pandemic, medical institutions actively adapt their teaching approaches to prevent infection. The medical model is the best learning tool to enhance medical practitioners' skills to the fullest potential without concerns.[16] Practitioners can practice individually with the model to compensate for practicing with patients. Moreover, the medical model can reduce instructional costs by repetitively use and being able to create the format related to instructors' guidance.[17]

A previous study demonstrated higher operation success rates after simulation training.[18] A VIST-C endovascular simulator is currently used in some cardiac catheterization practices. This high-precision device assists in practicing procedures as primarily visual responses in functional systems covering a wide range of vascular pathologies and standardized clinical complication situations in examination training. Using simulation scenarios significantly improved cardiac catheterization skills through training and reduced real device training process time in the Cath Lab.[19] A TSP simulation model was previously developed to train interventional cardiologists in cardiac catheterization. X-ray image simulation (fluoroscopy) and a wide variety of vascular pathology using 3D programs have also been used to assist real learning. Rating test results of the interventional cardiologists indicated the suitability of using simulation models; however, these results were not extensively tested because only interventional cardiologists were enrolled in the study.[20] Commercially available catheterization simulators include the ANGIO Mentor Suite produced by Simbionix Simulators, with simulation training of basic skills in Electrophysiology. However, this test does not cover the actual circulatory vascular system, while the simulation model looks like a box, lacks realism and does not match actual operation procedures. Simulation models for transradial catheterization operations are limited by their high cost.[21] Previous studies investigated the use of simulation models to practice complex procedures, with results showing reduced procedure time, fluoroscopy time and contrast media volume.[22] Studies on teamwork or computational safety of skilled participants are limited compared to assessments on simulation model realism and functionality.[23] To overcome these limitations, a half-body human-size simulation model was developed for trainee physicians to practice transradial catheterization via the radial artery in the wrist. The study subjects were fellowship students in the Interventional Cardiology Program.

MATERIALS AND METHODS

Artificial skin and radial artery selection steps following: 1) The three silicone rubber specimens that were all readily accessible on the market were analyzed. Each of the three types of silicone rubber had a Shore hardness value similar to human skin and the radial artery. Human skin has a Shore A hardness grade of 10 to 20, while the radial artery has a Shore A hardness grade of 37 to 39.[24-25] 2) The silicone rubber specimens were repeatedly punctured with an actual needle $20Gx^{1}/_{4}$ 1 in the exact location until a defect occurred as needle marks and tearing of the material. Survival analysis followed the Kaplan-Meier method. 3) Three experts evaluated the material qualities used to create the model. A questionnaire was used to collect information from the interventional cardiologist participants for model reliability, including Intraclass Correlation Coefficient (ICC) statistic, and 10 points were evaluated. 4) This experimental research measured the efficiency and satisfaction of the research population as 18 fellowship students from the Interventional Cardiology Program who had previous and no previous operation experience.

A half-body human-size simulation model, 108 cm high and 53 cm wide was created to improve transradial catheterization practice skills for the trainee physicians. Suitable materials were used to replicate the skin and artificial blood vessels. Three cardiologists conducted the testing procedure on 18 fellowship physicians in interventional cardiology studying the sub-discipline of cardiovascular disease treatment. Training using the simulation model consisted of two steps 1. vascular access and 2. catheter insertion to the coronary artery. (Figs 1 & 2)

Fig 1. Transradial catheterization simulation model

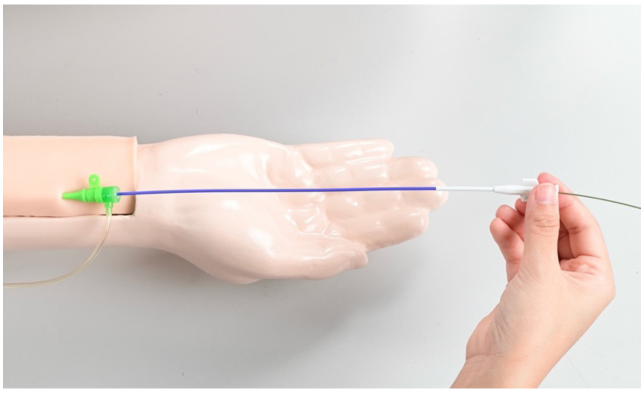

Fig 2. Coronary artery angiography training using the simulation model

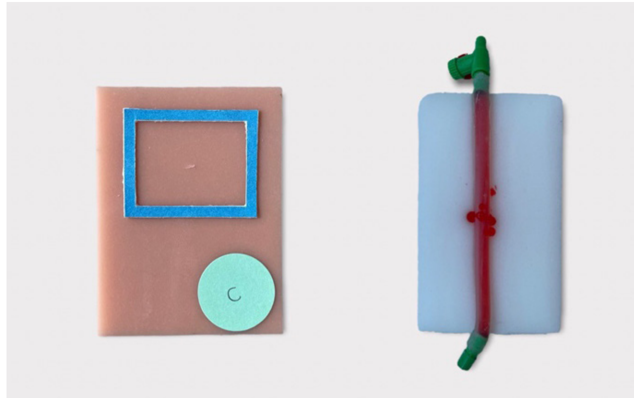

Fig 3. Survival analysis showing the needle punctures until the silicone rubbers were damaged

RESULTS

Silicone rubber durability test

Silicone rubber durability was tested by determining the number of needle punctures until leaving a needle mark and tear. (Fig 3) The durability results of simulated skin showed statistically significant differences at the 0.1 level (Kaplan-Meier method). RTV-01 silicone rubber gave a higher durability rate and minor damage than RTV-02 and RTV-03. The RTV-01 silicone rubber punctured the needle 75 times until leaving a needle mark, while the vascular access sheath was inserted 8 times until leaving a tear. (Chart 1)

The durability results of simulated vascular showed RTV-03 a higher durability rate and minor damage than RTV-02 and RTV-01, with statistically significant differences at the 0.1 level (Kaplan-Meier method). RTV-03 was able to puncture the needle to the skin 70 times until leaving a needle mark, and the vascular access sheath was inserted 12 times until leaving a tear. (Chart 2)

Reliability test results from the three cardiologists using Intraclass Correlation Coefficient (ICC) model analysis

The ICC values from the three cardiologists by estimating the three types of silicone rubber that were used to create the simulation skin, ICC = 0.88 (95% CI = 0.70 – 0.96). For vascular simulation, ICC = 0.88 (95% CI = 0.70 – 0.96) the expert confidence assessment results indicated consistency between the three experts and that they were of excellent reliability.

Satisfaction survey results from the fellowship of Internal Medicine Cardiology using a 5-point Likert scale

Values of resistance during needle puncture and catheter insertion were realistic with mean average score of 4.22. Skin softness and elasticity were real with an average score of 4.33. The shape of the simulation model was maintained after the procedure with an average score

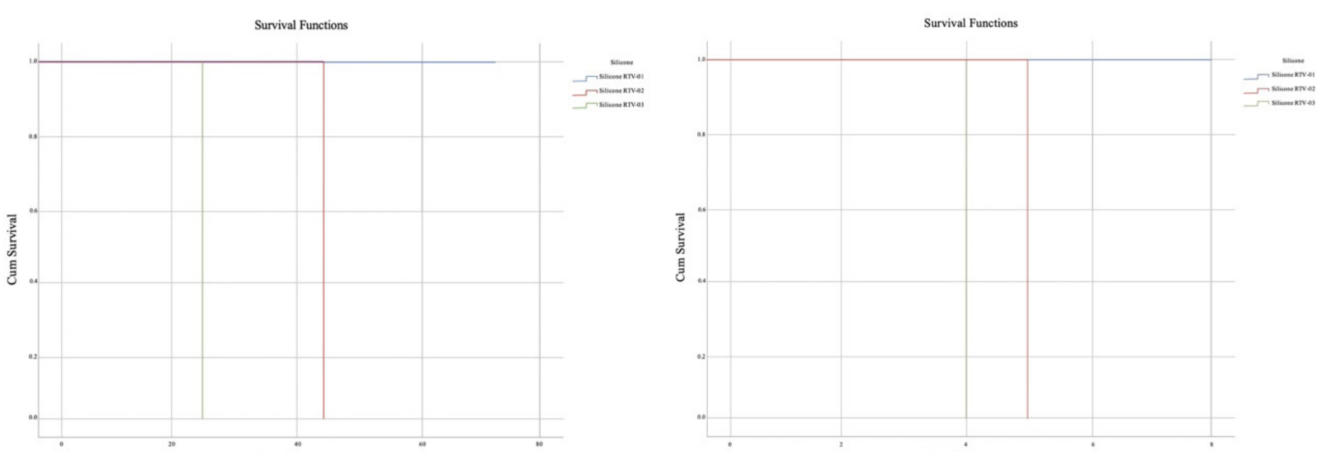

Chart 1. The simulated skin durability analysis (Kaplan-Meier) The number of needle punctures (left), and vascular access sheath insertion (right)

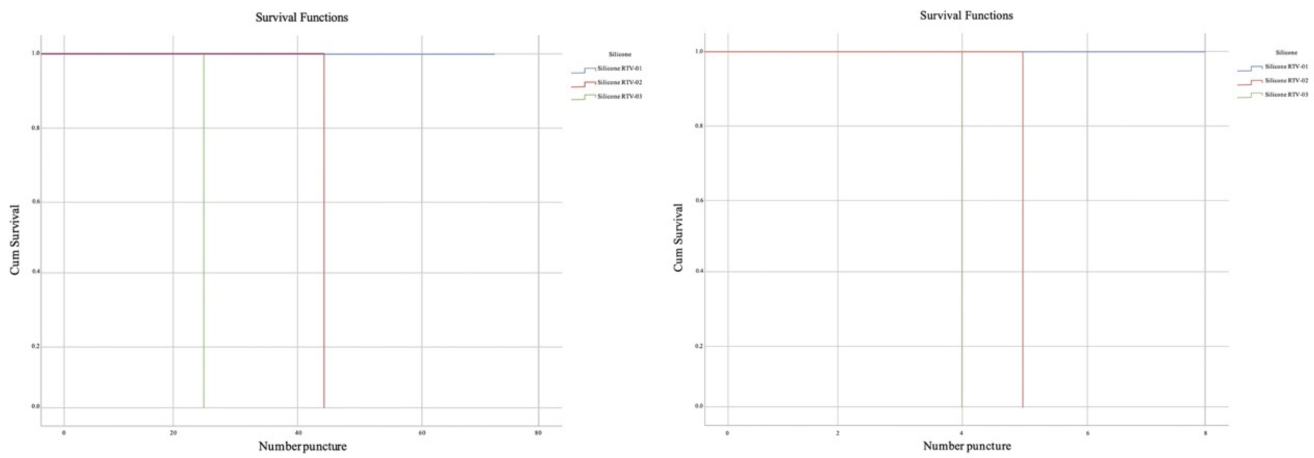

Chart 2. The simulated vascular durability analysis (Kaplan-Meier) The number of needle punctures (left), and vascular access sheath insertion (right)

of 4.50. The anatomical accuracy had an average score of 4.33. The blood flow was realistic with an average score of 4.33. The appearance of the model was suitable for usage with an average score of 4.78, and the total mean satisfaction of model performance had an average score of 4.41. These results showed that satisfaction with the performance of the model was at the highest level.

Satisfaction results showed that the simulation model enhanced the experience of the trainees with an average score of 4.67, reduced pressure before attending to an actual patient with an average score of 4.61 and increased confidence and readiness of the trainees with an average score of 4.56. Practicing the procedure in a controlled environment helped the trainees to prepare for potential problems with an average score of 4.50 and reduced the risk of performing the design on the patient with an average score of 4.61. The process for practicing the operation was realistic with an average score of 4.61, while total mean satisfaction with model usefulness recorded an average score of 4.59. These results showed that satisfaction with using the simulation model was at the highest level.

CONCLUSION

Simulation-based operational training is a valuable tool to increase learning efficiency and allows the fellowship trainees to practice operational techniques with the surgical equipment. Despite some simulators in cardiac catheterization training lacked realism due to their unrealistic form.[19,20] Lack of realism affects the surgical practice, which causes trainees to lack understanding of the procedure and the use of equipment. Therefore, researchers created a half-body human-size model to simulate an actual operation in which a patient is lying down on a surgical bed. Skin and vascular were mimicked as accurately as possible in terms of physical characteristics and capable of repetitive training. The materials can be reused and not accessible to tearing or leaving traces in operation. With

Fig 4. Transradial catheterization training

realistic and capability for repetitive training, transradial catheterization simulation motivates the fellowship trainees to become familiar with the equipment, gain a higher completion rate and increase confidence in treatment planning.

Recommendation

The study participants recommended developing a simulated pulse to the model that would make the practice of radial artery catheterization more realistic. A pulse would allow the participants to insert the needle correctly and reduce errors and damage to the skin and blood vessels.

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