Simulator training reduces radiation exposure and improves trainees' performance in placing electrophysiologic catheters during patient-based procedures

Roberto De Ponti, MD, FHRS, Raffaella Marazzi, MD, Lorenzo A. Doni, MD, Claudio Tamborini, MD, Sergio Ghiringhelli, MD, Jorge A. Salerno-Uriarte, MD

From the Department of Heart, Brain and Vessels, Ospedale di Circolo e Fondazione Macchi, University of Insubria, Varese, Italy.

BACKGROUND Currently, training in interventional electrophysiology is based on conventional methodologies, and a paucity of data on the usefulness of simulation in this field is available.

OBJECTIVE The purpose of this study was to evaluate the impact of simulator training on trainees' performance in electrophysiologic catheter placement during the early phase of their learning curve.

METHODS Inexperienced electrophysiology fellows were considered. A hybrid high-fidelity simulator (Procedicus VIST, version 7.0, Mentice AB Gothenburg, Sweden for Biosense Webster) was used. The following parameters were evaluated in 3 consecutive patient-based procedures before and after two training sessions of at least 1.5 hours on the simulator: (1) ability to place catheters in conventional recording/pacing sites (coronary sinus, His-bundle area, high right atrium, and right ventricular apex); (2) amount of help provided by the supervisor (scale from 1–3; 3 for maximal help); (3) fluoroscopy time; and (4) positioning time.

RESULTS Seven fellows performed 168 catheter placements during 42 patient-based procedures with no complications. Comparing parameters before and after simulator training, there was a significant reduction in the mean amount of help and in fluoroscopy and positioning times per placement: from 1.71 ± 1.24 to 0.42 ± 0.68 ($P < .001$), from 121 ± 88 seconds to 76 ± 54 seconds ($P < .001$), and from 175 ± 138 seconds to 102 ± 74 seconds ($P < .001$), respectively. Overall fluoroscopy time per patient decreased from 567 ± 220 seconds to 305 ± 111 seconds ($P < .0001$). Improvement appeared to be related to simulator training alone and not to the previously performed patient-based procedures.

CONCLUSION During the early phase of the trainees' learning curve, simulator training significantly improves the independent trainees' performance with reduction in radiation exposure.

KEYWORDS Electrophysiologic study; Interventional electrophysiology; Medical training; Radiation exposure; Simulation in health care

ABBREVIATIONS **CS** = coronary sinus; **His** = His-bundle area; **HRA** = high right atrium; **RVA** = right ventricular apex

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Introduction

Training in interventional electrophysiology is demanding and usually long-lasting. Within a predetermined time period (usually 1–2 years), the trainees must gain the necessary expertise in all of the procedural steps, from catheter placement to programmed electrical stimulation, from interpretation of endocardial mapping data to catheter ablation of simple and complex cardiac arrhythmias.[1] Currently, this training is based on the master/apprentice model, in which the trainee is exposed to a new procedure under the supervision of an experienced physician and is granted more independence as time and experience progress.[2] In many other medical disciplines, the use of simulators for educational purposes results in improved knowledge and skills, with a high level of satisfaction expressed by learners and instructors.[3] However, especially in the field of cardiovascular interventions, a paucity of data assessing the true clinical usefulness of simulators is available. Several studies have focused on improved knowledge and skills tested in the simulation setting. However, only a few studies have evaluated the impact of transfer of simulation learning to clinical practice and have provided positive but limited evidence.[3,4]

The aim of this study was to evaluate the impact of simulator training on the trainees' ability to place electrophysiologic catheters at conventional recording/pacing sites in order for a baseline electrophysiologic study to be performed. In patient-based procedures, the performance before was compared to that after simulator training, in the same group of trainees who were novices in electrophysiology.

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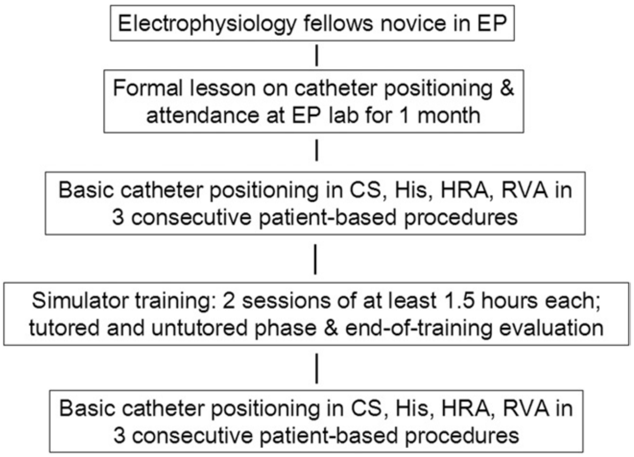

Figure 1 Study flow chart. CS = coronary sinus; EP = electrophysiology; His = His-bundle area; HRA = high right atrium; RVA = right ventricular apex.

Methods

Study design

The study flow chart is shown in Figure 1. The study was approved by the ethical committee at our institution. All patients signed informed consent.

Consecutive fellows with no prior experience in clinical electrophysiology were included in the study. During the first month of their electrophysiologic training, the trainees were given formal lessons on insertion, manipulation, and positioning of electrophysiologic catheters and the subsequent phase of the electrophysiologic procedure. While in the electrophysiology laboratory, the trainees were exposed to procedures performed by experienced physicians. After this period, under strict supervision, they placed electrophysiologic catheters in the coronary sinus (CS), His-bundle area (His), right ventricular apex (RVA), and high right atrium (HRA) in three consecutive patient-based procedures. The procedure parameters were recorded. Afterward, the fellows were exposed to the simulator for practicing of catheter positioning in the above mentioned locations. Simulator training was organized into two sessions of at least 1.5 hours each, with a tutored phase and an untutored phase. During the tutored phase, the tutor, in a 1:1 ratio with the trainee, showed catheter placement in the simulator and assisted the trainee in the initial virtual procedures. Subsequently, the fellow was free to practice catheter manipulation and positioning in virtual reality until he/she had acquired sufficient manual skills in the tutor's judgment. After simulator training, each fellow performed catheter placement in another 3 patient-based procedures, and the procedure parameters were recorded for comparison.

Simulator for basic catheter placement

The EP-SIM device, modified from the Procedicus VIST simulator (version 7.0, Mentice AB, Gothenburg, Sweden, in cooperation with Biosense Webster, Diamond Bar, CA), was used for simulator training (Figure 2). This device has been described in detail elsewhere.[4,5] In brief, the device is a high-fidelity hybrid simulator in which a haptic device (the "virtual" patient) is connected to a computer with dedicated software, which generates a 3-dimensional rendering of the human cardiovascular system. This device has 2 modules, which allow simulation of basic catheter placement and transseptal catheterization, respectively.

The basic catheter placement module allows introduction of electrophysiologic catheters through 2 ports in the superior and inferior parts of the haptic device (insets in Figure 2), which simulate venous access to the left subclavian and right femoral veins, respectively. Through these ports, multipolar catheters (10 or 4 poles) of different sizes (5F or 6F) and shapes (Josephson or Cournand) can be inserted, manipulated, and positioned in the right heart and into the CS under virtual fluoroscopy (Figure 3). Fluoroscopy appears real time on the computer screen when a pedal is pressed. On fluoroscopy, oblique projections are possible up to the latero–lateral projection. The catheters are real in their proximal part, while their distal portion is simulated by the software. Tracings simulating bipolar recordings in the CS and His appear on the computer screen only when catheters are correctly and stably positioned.

Performance evaluation before and after simulator training

For each fellow, the performance during the patient-based procedures before and after simulator training was evaluated by the same supervisor, in the same electrophysiology laboratory, using the same catheters for each specific site. In each procedure, the following parameters were recorded for each catheter placement in the CS, His, RVA, and HRA: (1) ability to successfully place the catheter; (2) amount of help provided by the supervisor; (3) fluoroscopy time; and (4) positioning time.

During the patient-based procedures, a catheter was correctly placed if stable recordings and pacing could be obtained in the absence of mechanical ectopies. Failure of catheter positioning was defined as the fellow's inability to

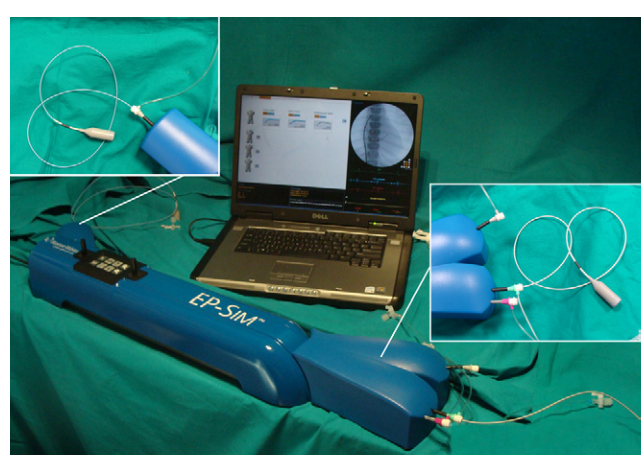

Figure 2 Electrophysiology simulator consisting of the haptic device (*front*) and a laptop computer with dedicated software (*back*). Magnifications of the venous ports simulating subclavian access and right femoral access are shown in the left and right insets, respectively.