Résumé

Réalité virtuelle en radiologie vasculaire interventionnelle : évaluation des performances

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Matériel et Méthode. Quarante-six radiologues simulèrent la réalisation d’un geste d’angioplastie rénale sur un appareil VIST (Mentice Corporation, Gothenburg, Sweden) ; ce geste était mené à terme par 41 opérateurs. La population était divisée en deux groupes selon le niveau d’expérience. Les variables quantitatives étudiées étaient la durée du geste et le temps de scopie. Les opérateurs remplissaient un questionnaire d’évaluation sur le simulateur.

Résultats. Les radiologues ayant plus de 2 ans d’activité (N = 14) mettaient moins de temps (20,4 minutes vs 27,4 minutes, p < 0,01) et utilisaient moins de scopie (7,8 minutes vs 11,2 minutes, p < 0,05) que les autres (N = 27). Les radiologues réalisant plus de 2 gestes par mois (N = 14) mettaient moins de temps (19,4 minutes vs 27,9 minutes p < 0,01) et utilisaient moins de scopie (7,4 minutes vs 11,3 minutes p < 0,05) que les autres (N = 27). Les participants indiquaient leur accord que les variables quantitatives étaient les critères permettant de différencier les utilisateurs suivant leur niveau d’expérience. Le travail sur simulateur était jugé utile pour l’apprentissage.


Abstract

Purpose. To determine the value of an angioplasty simulation to differentiate the users based on their level of experience. To determine the perceived usefulness of an angioplasty simulation program.

Materials and methods. Forty-six radiologists performed a renal angioplasty on a VIST simulator (Mentice Corporation, Gothenburg, Sweden); the procedure was completed by 41 radiologists. The radiologists were divided into two groups based on the level of experience. Quantitative variables analyzed included procedure duration time and fluoroscopy time. The radiologists then completed a questionnaire evaluating the simulation program.

Results. Radiologists with more than 2 years of clinical experience (n = 14) performed the procedures faster (20.4 min vs 27.4 min, p < 0.01) using less fluoroscopy time (7.8 min vs 11.2 min, p < 0.05) than others. Radiologists performing more than 2 procedures per month (n = 14) performed the procedures faster (19.4 min vs 27.9 min, p < 0.01) using less fluoroscopy time (7.4 min vs 11.3 min, p < 0.05) than others (n = 27). The participating radiologists indicated that the simulation was realistic.

Conclusion. Procedure duration time and duration of fluoroscopy were criteria able to differentiate the users based on their level of experience. The educational value of the simulation program was perceived as helpful by the users.

Key words: Virtual reality. Simulation. Learning. Interventional vascular radiology.

In most hospitals in Europe and the United States, the educational program for the third year of medical studies is based on the notion of “residency” which was developed by Halsted between 1904 and 1910. In the Halsted model, the learner (the resident) gradually and progressively acquires expertise over time by practicing in the hospital, by observing and treating the patient under the guidance and supervision of the teacher (1, 2). Nevertheless, this model is a problem when learning complex medical procedures.

Angiographies were the main vascular radiological procedure. The frequency and relative technical simplicity of these diagnostic vascular procedures were a first step in training for interventional vascular radiology procedures. The development and validation of non-invasive techniques (Angioscans and Magnetic Resonance Imaging) in the field of vascular radiology have significantly reduced the number of diagnostic angiographies. As a result, radiologists in training find themselves having to perform interventional procedures that require a certain level of skill in the choice and manipulation of tools. The need for a general reflection on training for medical procedures is especially pertinent for interventional vascular radiology (3).

In the United States, the study “To err is human…” reported between 44,000 and 94,000 deaths per year from medical errors (4, 5). According to this study,
more than half of these errors could have been avoided and the study recommended that simulation techniques (clinical situations, medical procedures…) be developed and used to improve the training of health care professionals and increase patient safety. Simulation training techniques have existed in fields other than medicine for many years. The most well developed example is in civil and military aviation. The first simulators were developed in medicine for surgical training in keyhole surgery, and for medical procedures and situations in intensive care (1).

Endovascular angioplasty simulators have been available for several years (1, 4, 6). In 2004 in the United States, the Food and Drug Administration (FDA) indicated that training on simulators could become a major part of the training program for practitioners to obtain certification for placing carotid stents (7, 8). More generally, training and continuous medical training using simulators may become a step in a validation and certification program for interventional radiology techniques.

The first aim of this study was to validate that a user’s level of professional experience and level of experience in interventional vascular imaging could be assessed by the simulator. The second aim was to evaluate whether users felt that simulators were useful for training and further training in angioplasty procedures.

Materials and methods

Forty six radiologists participated in the study which took place in the form of a two day workshop which was offered during a French Radiology Conference in diagnostic and interventional cardiovascular imaging. The study was sponsored by the French Society of Cardiovascular Imaging, (Société Française d’Imagerie Cardio-Vasculaire (SFICV)). Each participant had already performed vascular radiology procedures and had at least 6 months training in a vascular radiology unit. All participants had received prior theoretical training on endovascular material, on different indications for angioplasty and had manipulated endovascular material prior to the study.

Each of the participants performed a standard renal angioplasty procedure with the simulator (VIST, Mentice Corporation, Gothenburg, Sweden). The simulator included a physical device and a software device. The physical device included a dummy with a vascular structure in the form of a real removable parts allowing insertion of the endovascular material (guide wires, probes, lead catheters) (fig. 1). This material could be physically manipulated as if it were in a real situation (fig. 2). The device included two control screens and a pedal to simulate fluoroscopy andradiography to reproduce the different possibilities of an angiographic table. Injections of contrast medium were simulated by injecting air with a syringe at the end of the probe or the lead catheter (fig. 3). Inflation of a virtual angioplasty balloon was simulated by manipulating a real manometer attached to a pressure gauge. The software part of the device was used to select the types of guides and the forms and sizes of the probes, lead catheters, balloons and stents to be used. The material that was physically inserted into the dummy appeared on the screen during fluoroscopy as the selected material. A senior radiologist (SW) specialised in interventional vascular imaging was present during the session with the user and provided technical assistance for the practical use of the device. For less experienced users, practical advice could be provided by the senior radiologist but no manual assistance was provided. To establish a time limit, if the rigid guide was not positioned in the stenotic renal artery within 40 minutes, the simulation would fail.
Fig. 3: Selective arteriography simulation of the stenotic right renal artery. A rigid guide is first inserted into the artery through a preformed probe.

Results

Table 1 shows the distribution of the total population according to the amount of interventional vascular radiology activity and professional experience. 41 of the 46 participants successfully performed the renal angioplasty within the allotted time. There was no difference in the duration of the procedure or fluoroscopy time between radiologists who had never used a simulator and the others (table II). Radiologists with more than two years experience took less time and used less fluoroscopy time than radiologists who performed more than two interventional vascular radiology procedures per month took less time and used less fluoroscopy time than radiologists who only occasionally or never performed these procedures (table II).

Discussion

The main result of this study confirms that the angioplasty simulation device (VIST, Mentice Corporation, Gothenburg, Sweden) successfully differentiates users according to their level of experience on the basis of objective criteria (total duration of the procedure, and fluoroscopy time). The study did not reveal any need to provide specific training for the use of the device; no significant difference was

Table I

<table>
<thead>
<tr>
<th>Interventionsal vascular radiology experience</th>
<th>Professional experience</th>
</tr>
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<tbody>
<tr>
<td>Occasional</td>
<td>In training: 23, Experts: 8</td>
</tr>
<tr>
<td>Regular</td>
<td>In training: 7, Experts: 8</td>
</tr>
</tbody>
</table>
found between participants who had never used a simulator and those who had used a simulator at least once as long as a specialist provided technical assistance to operate the device. Studies have already been published on the use of an angioplasty simulator with similar results to those of the present study.

Aggarwal et al evaluated 20 participants separated into two groups according to their level of experience in interventional vascular radiology who performed a renal angioplasty simulation separated into four groups according to the level of experience (N=41).

Table II
Duration of the procedure and fluoroscopy time in relation to prior use of a simulator, professional experience, and interventional radiology experience (N=41).

<table>
<thead>
<tr>
<th>Prior use</th>
<th>Professional experience</th>
<th>Interventional radiology experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>Never used (N=26)</td>
<td>Once or more (N=15)</td>
<td>In training (N=27)</td>
</tr>
<tr>
<td>Duration of the procedure (min.)</td>
<td>24.4</td>
<td>26.0</td>
</tr>
<tr>
<td>Fluoroscopy time (min.)</td>
<td>9.8</td>
<td>10.4</td>
</tr>
</tbody>
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Table III
Responses to the individual questionnaire providing a subjective evaluation on a 5 point scale: 1) Strongly disagree 2) Disagree 3) Neither agree nor disagree 4) Agree 5) Strongly Agree summarized in the form of an average ± the standard deviation (SD) and type of distribution (N=46).

<table>
<thead>
<tr>
<th>Response</th>
<th>Mean ± SD</th>
<th>Mode</th>
</tr>
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<tbody>
<tr>
<td>The simulator realistically reproduces the angioplasty procedure</td>
<td>4.1±0.6</td>
<td>4</td>
</tr>
<tr>
<td>The tactile sensations are realistic</td>
<td>3.7±0.8</td>
<td>4</td>
</tr>
<tr>
<td>The catheter and angioplasty material reacts in a predictable manner.</td>
<td>3.7±0.6</td>
<td>4</td>
</tr>
<tr>
<td>The choice of material offered is appropriate</td>
<td>4.0±0.5</td>
<td>4</td>
</tr>
<tr>
<td>Working on a simulator is useful for training and further training of angioplasty procedures.</td>
<td>4.7±0.5</td>
<td>5</td>
</tr>
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</table>

requires the presence of an experienced user or a technician to adjust the machine and reset it if it becomes blocked. Progress needs to be made on the physical fragility of the system.

The results of the subjective evaluation of the study show that the participants felt that the simulation was realistic. Several simulators are available from different manufacturers; there are probably differences among the models, in the same model, and between models. In general improvements in software are developed rapidly thus increasing the realism of the “virtual world”; technological advances can also be expected in the field of angioplasty simulators. The cost of these devices is the main hindrance for their use in training and assessment, because there is a problem of funding. The French Society of Radiology via the Federation of Interventional Radiology is very aware of the need to develop this type of training.

Our study was based on users performing a standard renal angioplasty procedure. However simulation devices can be used for a wide variety of procedures: several types of angioplasty (carotid, renal, iliac, lower limb arteries, coronary…), with different anatomical structures for each territory. One of the goals of training is to provide experience in a variety of situations: the use of a simulator allows users to work in many different situations (morphological) in an optimal amount of
time since procedures can be performed at any time and successively. New versions for the simulation of embolisation procedures are being developed and will extend the line of available simulation procedures.

Working on a simulator limits the environmental factors of the angioplasty procedure, including those related to the patient. This allows users to concentrate on the practical aspects of angioplasty itself.

Another training technique for this complex medical procedure is training on animals. This requires a specific environment and also includes specific difficulties. The cost of training in animals is high, only a limited number of practitioners can be trained in one session, and experimentation on animals is an ethical problem. In a study comparing the two techniques from a pedagogical point of view, Berry et al. showed that the benefits of learning on animals seemed to be transferable to the use of a simulator (14). Of course, learning to perform a technical procedure is not an end in itself. Knowledge of anatomy, physiopathology and drug therapy are essential to determine an indication, to perform and follow up a procedure. Training in a technical procedure should be part of global training program in all aspects of this field. The use of a simulator is one aspect in the training and continuous medical training for the angioplasty procedure. Besides the individual benefits, this method can be used to evaluate the impact of pedagogical approaches (training sessions, clinical vascular imaging training sessions...) to this procedure. The next step would be the use of simulation as a tool to validate training and obtain certification (15). The medical societies (Cardiovascular and Interventional Radiological Society of Europe, Society of Interventional Radiology, Radiological Society of North America) have begun a work group on this subject (16). This “task force” has emphasized the importance of simulation for learning each step of the sequence in the angioplasty procedure, as well as for choosing material. This task force also indicated that additional studies were needed, in particular to better define the performance indicators of a simulated angioplasty procedure. Nevertheless, it seems clear that work on a simulator should be part of the basic training for every resident in radiology. The authors hereby declare that they have no conflicts of interest.

References