E-Learning Templates for Peripheral Vascular Stenting

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***Abstract*—The RT3S (Real Time Simulation for Safer Vascular Stenting) training application is designed to enable tutors (expert surgeons) prepare educational content for their students, and the students (future surgeons) to be trained on the assessment of real patient cases on peripheral vascular stenting. It incorporates state-of-art technologies (i.e., Learning Activity Management System - LAMS) for system design and adopts the latest e-learning standards (i.e., IMS Learning Design) for the implementation of training scenarios. In this work, we focus on the structure of the clinical scenarios that constitute the core of the RT3S training application. In RT3S training application, creating or accessing learning scenarios does not require that the author (tutor) or the learner (student) be familiar with any programming environment. The learning scenario allows the learners to follow an educational scenario and interact with their tutor.**

Keywords— training scenarios, peripheral arteries, stenting

I. INTRODUCTION

Peripheral vascular disease (PVD) is a condition of the blood vessels that leads to narrowing and hardening of the arteries that supply the legs and feet with blood. The narrowing of the blood vessels leads to decreased blood flow, which can injure nerves and other tissues. The treatment of PVD depends on the severity of the disease and typically suggests modifying cardiovascular disease risk factors and finally angioplasty, bypass graft and amputation.

Decision making for the peripheral vascular disease can be quite complex as a result of pre-existing compromise of patient functional status, anatomic considerations, uncertainty of favorable outcome, medical comorbidities, and limitations in life expectancy. Treatment decisions require expert knowledge by an experienced doctor. In the context, for training young vascular angioplasty surgeons, several training systems are known to exist [1-10] with the most popular being Simbionix (Simbionix Ltd, Israel), Therenva (Therenva, Rennes, France) Mentice (Mentice, Gothenburg, Sweden) and CAE Healthcare (CAE Healthcare, Montreal, Canada). All these, are commercial systems designed and tailored around some specific purpose or application. Typically, they all provide with a realistic environment offering a wide range of training possibilities to health care professionals such as surgeons or nurses. The Society for Cardiovascular Angiography and Interventions (SCAI) [7], NHS [8], WeBSurg [9] and the Surgical Technologist [10], are Web-based training applications specializing on safer vascular stenting, and in this regard, are most relevant to the training concept of the present work. The applications referred to above rely on incorporating high quality slides, images, video, audio or animation within step-by-step descriptions of real educational scenarios, case studies, surgical protocols as well as, on incorporating descriptions of equipment and well established operative techniques within their training scenarios. An inherent limitation of all these educational systems is that, the editors of the scenarios need to be system experts, rather than clinical experts (who provide the system experts with content and clinical know-how), as most of these systems require that the editor of a scenario be familiar with the peculiarities of the system. Both kinds of experts have to work close together which may be time consuming and expensive. In addition, reusing content or parameterizing the underlying authoring environment to receive new, or reuse existing content for adapting or creating new training scenarios, is not easy and requires substantial effort.

In this work, a detailed description of the structure of the clinical scenarios, which are the core part of the RT3S (Real Time Simulation for Safer Vascular Stenting) training application, is provided and discussed. The RT3S training application is a formative module of the RT3S system with adapted contents to allow learners to simulate the result of interventions and learn to make better decisions before undertaking practical cases concerning the management of patient with peripheral vascular diseases, increasing thus safety in clinical procedures.

The rest of the paper is organized as follow. Section II provides a short description of the RT3S system and more specifically of the training application. In Section III each stage of the RT3S training scenario template is presented while in Section IV some concluding remarks are discussed.

II. RT3S TRAINING APPLICATION

The RT3S system [11] aims to transform the planning of endovascular procedures to treat peripheral arterial disease. RT3S will: (a) develop a software toolbox capable of

computing, in real-time, the risk of fatigue fracture for stents used in peripheral vascular angioplasty and stenting, (b) release a complete software product for pre-operative planning of peripheral vascular angioplasty and stenting and the prediction of the risk of stent fracture, (c) provide companies operating in the cardiovascular device market with a complete simulation environment for the prediction of the risk of stent fracture, (d) develop a data management tool and innovative visualization methods to support clinical and training practice [11]. Addressing the last objective is achieved by means of a training application.

The RT3S training application is a novel tool for designing, managing and delivering online collaborative learning activities. The RT3S training application adopts the latest e-Learning standards such as, IMS Learning Design (IMS LD) [12-13] for the implementation of training scenarios on the Web. It provides tutors with a highly intuitive visual authoring environment for creating sequences of learning activities of increasing difficulty, can address different user types for different educational objectives, and is easy to use by clinical experts (i.e., it does not require the author of a scenario be familiar with the LAMs environment) [14]. Learning activities range from individual tasks and small group work, to class activities. Furthermore, it offers tutors a customizable distance learning solution for training or examining their students at any time and any place. The RT3S training application is available on the Web [15].

The RT3S e-Learning tool provides the required functionality for presenting, accessing, importing and exporting information about patients and their examinations. This is realized as an E-learning software template (i.e., an empty scenario depicting learning stages) providing access to a set seven predetermined learning stages forming the main building blocks of an E-learning scenario [16]. To increase flexibility in crafting new scenarios, selecting of learning stages for composing a scenario depends on the learning needs of the trainee and of the scenario. In addition, each stage is easily customizable (allowing the tutor to define the functionality he/she has in mind). Each learning stage is also enriched with a repertoire of tools (functions) for developing the desired learning goal. Both actions (i.e., scenario composition by selecting learning stages and putting them in a learning sequence, customization of learning stages) are implemented by means of a Graphical User Interface (GUI) using buttons and pull down menus (Fig. 1).

The RT3S training application suggests a learning environment demonstrating possible treatment solutions in peripheral vascular stenting as well as their implications in patient's life in the case of wrong treatment decision. Its contents can be easily adapted to the learning objectives and may include engineering simulation results from stent and cardiovascular devices design. Also, the training application can integrate engineering simulation results, such as models of arteries, strain and stress results, definition of a fatigue test, helping users to understand concepts such us modeling and simulation as well as, their utility and significance [17].

The key characteristics of the learning process are: a) a scenario can be easily adapted to the educational objectives and the needs of each trainee, b) the training process is interactive allowing the trainer to interact with the scenario and with their trainees and also, take the initiative on suggesting treatment plan for patient and receive feedback e.g., suggestions, c) at certain steps of the scenario, the trainee is opted to take decisions and depending on these, follow different pathways leading to different results e.g., risk factors, possible affects and complications.

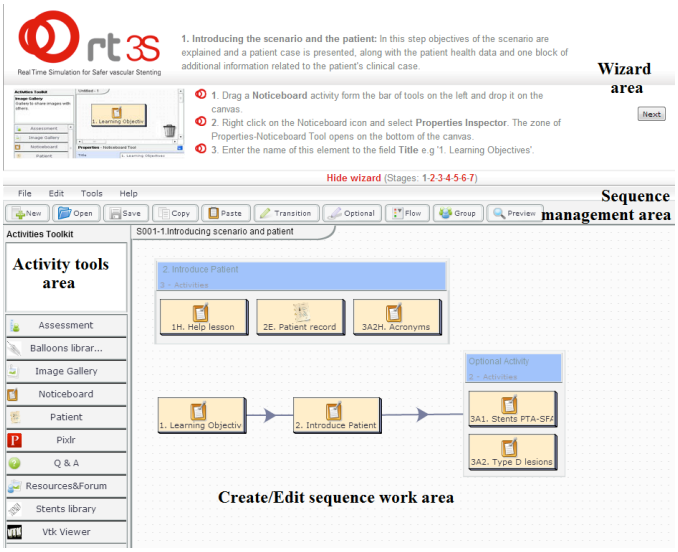

Fig. 1 Graphical user interface of the authoring environment.

III. RT3S TRAINING SCENARIOS TEMPLATE

The RT3S training scenarios template comprises of seven stages. The order of the stages and the content of the stages simulate the process followed in clinical practice for the management of a patient who enters the hospital with peripheral vascular disease signs and symptoms. For example, a 65-year-old man enters the hospital reporting pain in one calf after a brief walk but the pain goes away if he stops walking. The doctor completes or reviews the patients' record (Stage 1). Based on medical / family histories and physical examination (Stage 2), the doctor refers him for a Magnetic Resonance Angiogram (Stage 3). Obstruction is identified in the popliteal artery due to an occlusive atherosclerotic plaque (Stage 4). The vascular surgeon imports the patient's images into AimaSimul and selects stents of different designs and sizes. Based on the patient-specific anatomy, the fracture risk for each stent is calculated and a risk index is provided to the surgeon (Stage 5). The doctor, taking into consideration the previous results, suggests patient to be subjected to angioplasty and stenting (Stage 6). The whole procedure is described in angioplasty report (Stage 7) stored in the patients' record.

Fig. 2 illustrates a generic training scenario comprising of up to seven learning stages. One or more stages may be omitted depending on user needs. The scenario is represented as a sequence of identical tasks (each one corresponding to a learning stage) and by information flowing from one stage to another. Each scenario has to be realistic and represent a procedure for peripheral vascular angioplasty, which is

authored, based on expertise by medical experts (can be the authors of the scenario).

A. *Introducing scenario and patient*

A scenario starts by presenting the learning objectives and learning benefits (Fig.3) to the trainee. In RT3S training application, the learning objectives range from explaining the various steps involved in the management of a patient and going through the decision process during the assessment of a vascular condition to selecting the endovascular materials and designing the endovascular procedures based on the estimated risk fracture. Initially, the trainee is granted accesses to patient information under consideration (user case). Patient information may include patient medical history, demographic details (age, sex), risk factors (family diabetes, cholesterol, hypertension, smoking, and obesity), symptoms causing their hospitalization, current diseases, historical data (cardio vascular, pneumatology, nephrology related, allergies, surgeries etc.), drugs and medication intake, lab tests. This information is accompanied by various imaging examinations of the patient (ultrasound, MRI etc.) and is stored in the RT3S database.

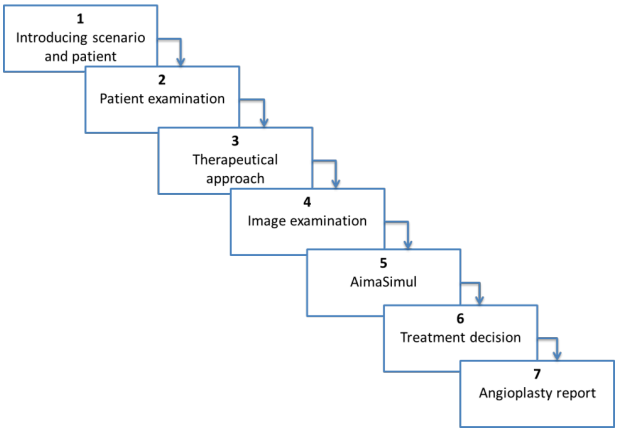

Fig. 2 Learning stages of the training scenario.

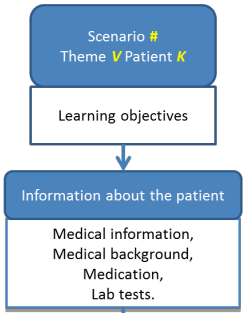

Fig. 3 Stage 1: Introducing scenario and patient.

B. *Patient examination*

Taking into consideration all the available patients information, the trainee is prompted to make an initial assessment for their condition (Fig. 4). This can be achieved through an assessment procedure including different types of questions (multiple choice, matching pairs, true/false, essay, ordering etc.). Because a learning process is generally meant to be an interactive process, the trainee may receive feedback (e.g., from a tutor or expert surgeon) to prevent him/her from making mistakes in the following steps. For example, in RT3S, the clinical procedure that the trainee should follow for the diagnosis of peripheral arterial disease according with the appropriate explanation and justification is provided. Finally, the results of the patient under consideration are returned to the trainee in order to allow him/her to select the appropriate therapeutical approach.

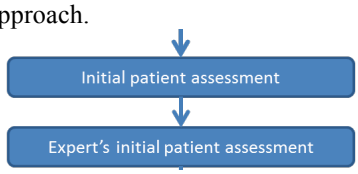

Fig. 4 Stage 2: Patient examination.

C. *Therapeutical approach*

In the following step, the trainees are prompted to suggest a treatment plan (e.g. smoking cessation, diabetes management, antiplatelet and lipid-lowering therapy, daily exercise etc.) depending on the level of their experience (e.g., a medical student does not have the same experience with a doctor following a residency program) (Fig. 5). This can be achieved through a branching activity leading to multiple learning path-ways. In particular, learning branches can be created with one of the following two ways: a) the tutors monitors the trainees and they manually assign branches to specific trainees, b) the results from previous activities can determine which branch a trainee must follow. The aim of the branches is the learners to be guided, through further educative activities, to the suggestion of the correct therapeutical approach and simultaneously understand which assumptions made them to deviate from the correct assessment of the patient case. The trainees compare their suggestion with feedback provided by the expert or tutor.

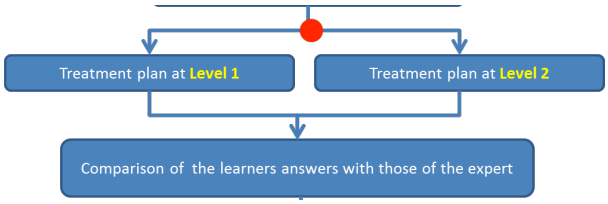

Fig. 5 Stage 3: Therapeutical approach.

D. *Image examination*

In the next (fourth) step, the imaging examinations of the patient are presented to the trainee. Different possibilities are provided to the trainees. They can preview annotated video and images of the patient under consideration and/or they may be asked to annotate medical images of the patient (Fig. 5).

E. *AimaSimul*

The trainee is opted to use AimaSimul [18] for generating the 3D artery model and define the region of interest (e.g., stenotic area). This step allows the trainee to have a clear view of the problem and then select appropriate endovascular materials to be placed at a specific position on the artery. In response to the placing of e.g., a stent, the application returns

the pre-calculated fatigue fracture risk [17]. Visual results of the placing of stents are also presented to the trainee (Fig. 6).

F. Treatment decision

By combining the imaging examination with fatigue fracture risk assessment results the trainee proposes the final treatment for the patient (e.g. angioplasty, amputation, bypass etc.). Depending on the treatment proposed by the trainee, the experts provide with their assessment (Fig.7) explaining the conditions which allow the application of each treatment plan.

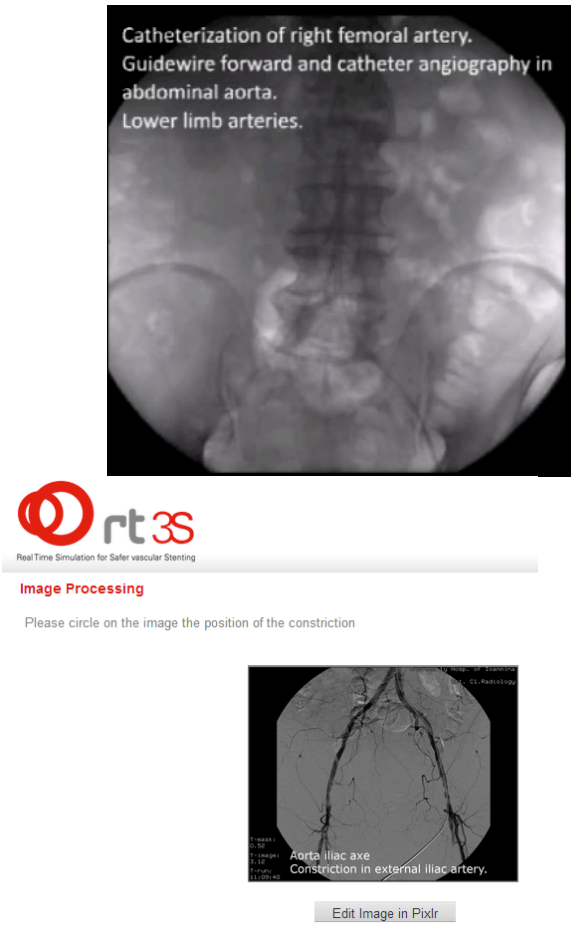

Fig. 6 Stage 4: Imaging examination.

All the necessary information is concentrated in a report. This report includes a) study general parameters (patient id, birth date, sex etc.), b) artery general parameters (vessel length, diameter etc.), c) stenotic zone parameters (stenosis position, diameter, global torsion, global curvature, tortuosity, max stenosis ration, section length, tapering), d) simulation parameters (conic ratio, diameter, length, asymmetry, residual lumen, sharpness, vessel rapture risk, stent fatigue fracture risk), e) stent parameters (company, model, delivery system, material, diameter, length, thickness), and f) images.

G. Angioplasty report

The trainee completes the angioplasty report and compares it with one that has been completed by the expert (or one retrieved form the RT3S database). The scenario concludes with the final assessment by the trainer on the performance of the trainee (Fig. 8).

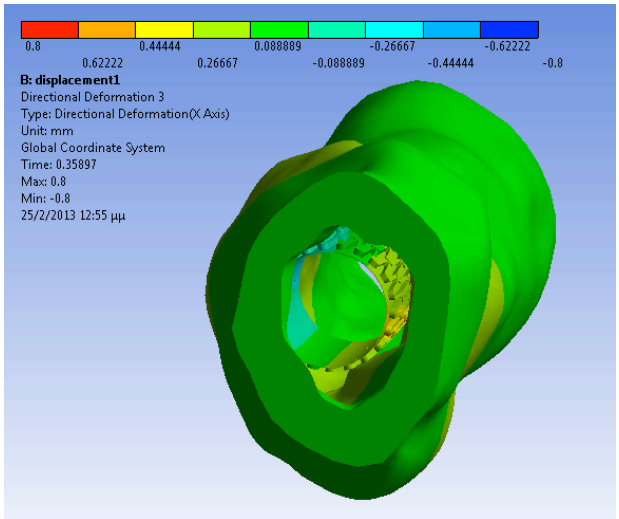

Fig. 7 Visual results provided to the trainee.

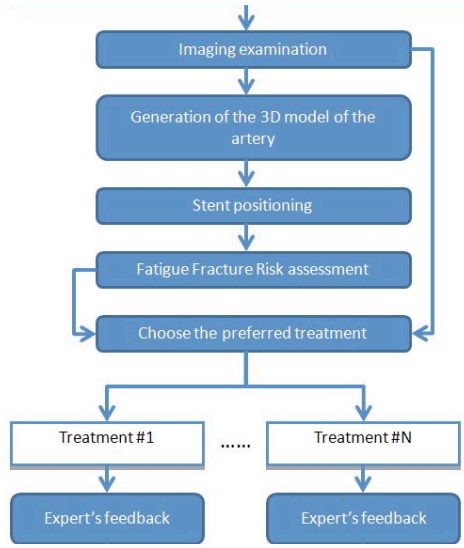

Fig. 8 Stage 6: Treatment decision.

Fig. 9 Stage 7: Angioplasty report.

IV. CONCLUSIONS

We suggest the structure of clinical scenarios for training future angioplasty surgeons. The scenarios are represented as a flow of tasks plus data in a way that is governed by rules or procedures for peripheral vascular angioplasty. Enriching the application with real-life vascular stenting use cases, as well

as, the evaluation of the RT3S training application by specific target groups are natural next steps for future work.

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