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WORKFLOW SIMULATION APPLIED TO IMAGE-GUIDED PROCEDURES. UNDERSTANDING THE PRESENT AND LOOKING TO THE FUTURE.

Fabiola Fernández-Gutiérrez
Andreas Melzez

Institute for Medical Science and Technology.
University of Dundee
Wilson House, 1 Wurzburg Loan
DD21FD Dundee, UNITED KINGDOM

Avril Barclay
Graeme Houston

Clinical Radiology Department. Ninewells Hospital

DD19SY Dundee, UNITED KINGDOM

Thomas Martin

Cardiology Department. Ninewells Hospital
DD19SY Dundee, UNITED KINGDOM

ABSTRACT

Workflow simulation has been used successfully in surgical environments improving efficiency and patient care. Imaging Operating Rooms (IORs) have specific requirements in terms of equipment, safety and ergonomics that make them challenging for workflow studies. Most authors have looked into scheduling and waiting list improvement for radiology environments; few go beyond. We present here a case of study of peripheral and cardiac angioplasty and stenting based on data collected for iliac angioplasty in Ninewells Hospital (Dundee, UK). This model includes detailed workflow description, patient data, role interactions between clinicians during interventions, etc. Records and mathematical relations between interventions' events were analyzed prior to model implementation in Delmia Quest. This is a work in progress that aims to provide a better understanding of the procedures, helping on the development of new procedures for new scenarios, for example, moving from X-ray driven to Magnetic Resonance (MR) guided interventions.

1 INTRODUCTION

Image-guided interventions are gaining importance as a real alternative to open surgery, especially in case of endovascular and cardiovascular procedures (ECVP). Therefore, there is a significant interest on improving workflow and ergonomics in this field. These efforts have focused mainly on scheduling practices and resource utilization (Johnston et al. 2009). A recent review about the use of simulation in radiology by Lindsköld et al. (2008), highlights the potential of this technique to support proper planning and use of personal and equipment, revealing also the lack of studies that explore simulation as a tool that facilitates innovation and integration of different imaging technologies. In this work in progress, we present the models for standard peripheral (iliac) and cardiac angioplasty and stenting procedures as ECVP representatives based on data collected in Ninewells Hospital (Dundee, UK). These models will help in the optimization of the current workflow and in the development of formal workflow protocols for ECVP under multi-modal imaging guidance, e.g. under MR and Ultrasound.

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2 MATERIALS AND METHODS

A total of 43 records (10 iliac and 33 cardiac angioplasty and stenting (ICAS) procedures) were collected through templates, attending the procedures and interviewing clinicians, and a database available at the Cardiology Department in Ninewells Hospital. A website and a database were used to facilitate the posterior analysis. Table 1 shows a summary of the data collected and the statistical analysis performed over the records. In addition, independent and Goodness-of-Fit tests were done with the samples as well as a preliminary evaluation of possible mathematical relations between events with the objective of finding hidden surgical patterns.

Data set	**Description**	
Patient data	Gender/Age/Height/Weight	
Procedure	Name/Previous procedures/Pre-images	
Staff	Role/Number/Sterilized/Experience	
Supplies	Type/Model/Manufacturer	
X-Ray dose	Emitted/Absorbed dosage and period	
Contrast	Contrast details/amount	
Complications	Time/Summary	
Event log:	**Event**	**Distribution**
	Preparation time	Gamma
	Access time	Gamma
	Guidance time	Weibull
	Balloon procedure	Lognormal
	Stent procedure	Weibull
	Cleaning	Weibull

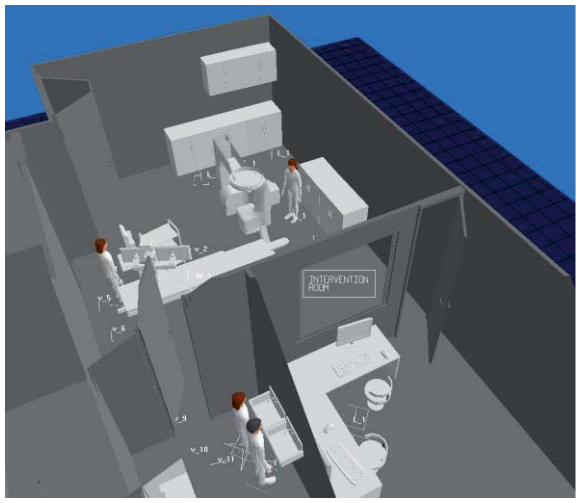

Table 1. Data and statistical distributions fitted to events collected. Figure 1. Model in Delmia Quest of an Angiography suite at Clinical Radiology Department at Ninewells Hospital (Dundee, UK).

3 RESULTS

The statistical analysis for ICAS interventions indicates that both types of procedures follow similar distributions although the parameters are different for each other. The mathematical analysis performed over the events hasn't revealed any relation between phases. This analysis will be completed using more advanced probability analysis, e.g. principal component analysis.
Models for both standard procedures have been implemented in Delmia Quest (Fernandez-Gutierrez et al. 2012) (See Figure1). This models, in development, include human and equipment resources in order to analyze costs and effectiveness. The results will lead into the development of new work flows in multimodal imaging scenarios that present several challenges in terms of costs, safety and resources.

REFERENCES

Fernandez-Gutierrez, Fabiola, Iain Barnett, Bruce Taylor, Graeme Houston, and Andreas Melzer. 2012. "Framework for detailed workflow analysis and modelling for simulation of multi-modal image-guided interventions." *JEIM Special Issue on Healthcare Operations Management* (Accepted).

Johnston, MJ, P Samaranayake, A Dadich, and J A Fitzgerald. 2009. Modelling radiology department operation using discrete event simulation. In *MODSIM, International Congress on Modelling and Simulation*, 678-684. Cairns, Australia.

Lindsköld, L., P. Aspelin, B. Jacobsson, and N. Lundberg. 2008. "The use of simulation in radiology." *Radiology management* 30 (3): 55.