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A new kind of training for obstetric residents: simulator training

Richard Moreau, Audrey Jardin, Minh Tu Pham
Tanneguy Redarce, Osama Olaby
Laboratoire d'Automatique Industrielle (LAI)
INSA de Lyon
69621 Villeurbanne Cedex, France
richard.moreau@insa-lyon.fr

Olivier Dupuis
Hôpital de la Croix Rousse
Hospices Civils de Lyon (HCL)
69314 Lyon Cedex 04, France
olivier.dupuis@chu-lyon.fr

Abstract— **This paper presents work resulting from a collaboration between obstetricians and researchers. It shows the benefits from the use of an instrumented childbirth simulator for the training of obstetricians and midwives. This new tool allows to surpass the constraints linked to the traditional training in a childbirth ward. This simulator training is designed to complete the traditional training used in teaching hospitals. Such a training allows residents to acquire a beginning experience before training in a childbirth ward but it also allows instructors to improve the teaching gestures without constraints. A clinical study of the forceps blades placement gesture with several residents who trained on a childbirth simulator is made. The results clearly show the progress in the obstetric gestures of all the residents who have used the simulator.**

I. Introduction

Generally, the aim of a simulator is to allow people to learn or to teach how to carry out a complex specific action. As is the case in aerospace [1], in aeronautics [2] or in transport [3] a simulator offers a risk free training to future professionals and allows them to acquire a minimum of experience before acting in real. In aeronautics, the flight training is preceded by a compulsory simulator training period. In the same way, in the medical field several companies have developed medical simulators [4]–[6]. Simulators are now available for example, in laparoscopic surgery [7], endoscopic surgery [8] or in orthopedy surgery [9].

In obstetrics, none complete tools for the training is available [10], therefore the *Laboratoire d'Automatique Industrielle (LAI)* and the *Croix-Rousse hospital* have developed a birth simulator: the BirthSIM simulator [11] and its instrumented forceps [12] have been designed to complete the traditional training in the childbirth ward. The simulator allows young obstetricians to acquire experience in various obstetric gestures (transvaginal assessment diagnosis, eutocic childbirth, instrumental childbirth by forceps). A simulator training is also used to train in particularly rare cases with various degrees of difficulty or to validate new instruments and new techniques and to evaluate capacities.

One of the advantages of a simulator is to by pass the constraints occurring in a childbirth ward during obstetric gestures training. During an instrumental childbirth with a forceps these constraints are [13]:

- In space: The gesture occurs inside the maternal pelvis and thus the residents do not see the instructor gestures and reciprocally instructors can not validate the residents gestures;
- In time: When an instrumental delivery happens, it has to be carried out as an emergency;
- Stress linked: The first forceps extractions carried out by residents are always awkward because of the risks incurred by the fetus;
- Rarity of the gestures: It is difficult to learn and to teach a gesture learned and taught by experience which does not occur often as instrumental childbirth is not a scheduled event.

The main goal of this paper is to show the advantage of a simulation tool within the scope of obstetrics. This paper is divided into three parts, the first part presents the tools used and the setting of the experimental protocol. The second part is devoted to the evolution of an obstetric gesture realized by residents with the simulator. The obstetric gesture involved is a forceps blades placement for a cephalic presentation. Finally, the last part will discuss these results. In conclusion we will present the works in progress and future research.

II. Tools and methods

A. The BirthSIM simulator and its instrumented forceps

The BirthSIM simulator has been used for the simulator training. This simulator consists of three components: mechanical, electropneumatic, and visual [10]. A principle diagram is shown in figure 1. Residents can have haptic feelings on the mechanical component which accurately reproduces the maternal pelvis and a fetal head with their particular anatomical landmarks (ischial spines, coccyx, sacrum, and pubis for the pelvis and fontanels, sutures, and ears for the fetus). During this study, the training procedure used also the visual component. This component allows residents to be submerged inside the maternal pelvis and to see the instrumented forceps displacement around the fetal head (figure 2). A forceps has been instrumented with two (one in each blade) six degree of freedom sensors [14]. It can also be used by the instructor to explain obstetric gestures. Concerning the electropneumatic component, it is not involved in this study because it is based on the quality of the forceps blade placement and not on the extraction.

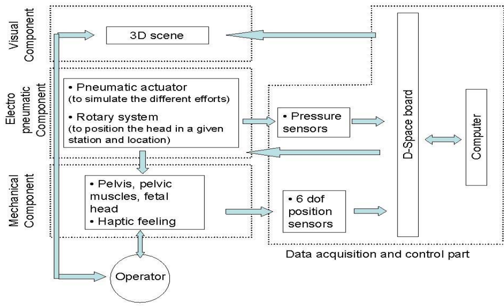


Fig. 1. Principle diagram of the BirthSIM simulator

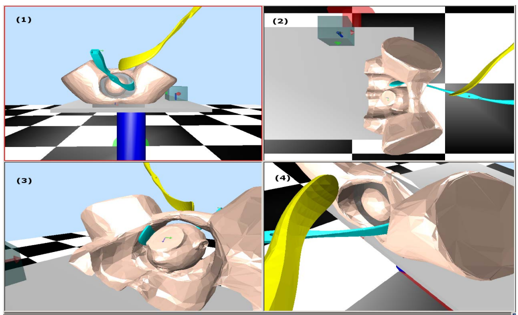


Fig. 2. The visual component of the BirthSIM simulator

B. Experimental protocol

Two residents (R1 and R2) in first semester of obstetrics and one in his third semester (R3) were chosen to test the simulator training. The simulator training is supervised under the authority of an obstetrician expert who is the instructor. An experienced obstetrician is defined as having had ten year of experience, and using forceps in more than 80% of his interventions. The fetal head is positioned according to the ACOG (American College of Obstetrics and Gynecology) classification [15]. The presentation is cephalic, that is to say the head comes in first and corresponds to a station and location OA+2 (Occiput Anterior location and station +2cm from the ischial spines plan).

The training lasted three days at the rate of one hour a day. At the beginning of the training, the residents placed the forceps as they will do in the childbirth ward without any advice of the expert. Then during the training, the expert explained to them how to correctly place the forceps using the mechanical and the visual components of the BirthSIM simulator. The residents placed ten forceps per training day. Their gestures were recorded progressively throughout their training which enabled their evolution to be followed. Three gestures per day were recorded and analyzed to see their evolution in time. At the end of the training nine measurements for each resident were obtained.

C. Method of analysis

To follow the evolution of the forceps blades placement, the two methods described in [12] are used. One of these methods of analysis enables the repeatability of the residents gestures to be measured. This method is based on the study of three particular points of trajectory (departure, return and arrival points). It calculates the smallest spheres gathering each one of these points on three trajectories. The smaller are the spheres the more the operator gestures are repeatable. The analyzed trajectories are gathered in three groups, a group per day of training. To define the degree of repeatability, the value of the sphere radii is analyzed.

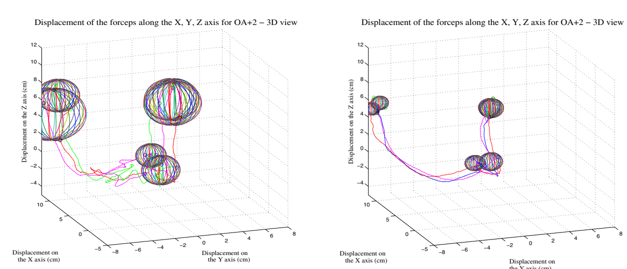
Concerning the second method, it enables the evolution of their error compared to a reference obstetric gesture to be followed. The reference obstetric gesture was previously extracted from the records of the expert gestures. This method calculates the error between the residents gestures and the expert ones. As operators do not need the same time to place the forceps, trajectories had to be normalized according to an average time calculated from all the expert measurements (5.1 seconds to place the left blade and 6.8 seconds for the right blade). This method is more complete than the previous one because it takes into account the whole trajectory and not only three particular points like the preceding method. To complete this analysis, the forceps blades placement duration was also recorded in order to be analyzed.

The two methods of analysis are complementary and enable the evolution of the residents to be followed during their training on the BirthSIM simulator.

III. Results

A. Repeatability of the gesture

The figure 3 shows the paths at the beginning of the training and at the end of the training for resident R3. In studying the paths, the most interesting point to follow is the tip of the blade. In fact it is this part of the forceps which is potentially dangerous because it is in permanent contact with the fetal head; it must surround the head to take position behind the fetal ears. Therefore the path of the forceps blade tip is plotted on the following figures.



(a) Before the training (b) After the training

Fig. 3. Trajectories of the resident R3 with the repeatability spheres

Qualitatively, one observes on these figures that the gestures seem to be less hesitant and more similar to each other. Similar figures were obtained for residents R1 and R2, they have not been plotted to avoid repeating the same kind of figures, as we mainly are interested on the quantitative analysis.

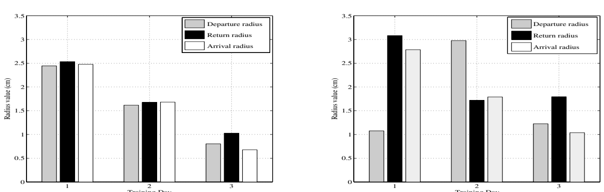
From a quantitative point of view, the radii of the spheres including the particular points are studied and enable the criterion of repeatability to be defined. Table I gathers the obtained results. The nine forceps blades placements are gathered in three groups according to the training day.

Station and location OA+2		Resident R1		Resident R2		Resident R3	
Day	Sphere	Left blade	Right blade	Left blade	Right blade	Left blade	Right blade
1	Start	1.29	0.73	2.78	1.23	2.44	1.08
	Return	4.18	2.13	3.49	2.55	2.53	3.08
	Arrival	1.91	1.19	2.24	2.17	2.48	2.78
2	Start	1.34	1.14	1.80	2.62	1.62	2.98
	Return	1.62	1.57	1.20	1.83	1.68	1.72
	Arrival	1.86	1.41	1.20	1.67	1.68	1.79
3	Start	1.21	1.06	1.34	1.83	0.80	1.22
	Return	0.93	0.96	0.47	1.10	1.03	0.93
	Arrival	0.81	1.26	0.42	1.48	0.68	1.04

TABLE I

TABLE OF THE RADII SPHERES IN CM FOR RESIDENTS R1, R2 AND R3

The figure 4 represents, in a histogram form, the evolution of the radii spheres according to the training day.



(a) Left forceps blade (b) Right forceps blade

Fig. 4. Evolution of the spheres radii for resident R3

For the same reason as previously stated (similar results) only one figure is shown to avoid overloading the paper with similar figures.

An overall reduction of the values of the radii is noticed what means that the residents carry out gestures in a more and more repeatable way. The residents thus seem to have acquired a gesture with a higher degree of repeatability. However their trajectories were studied on only three particular points. To complete this study we analyze the trajectories as a whole and they will be compared to the reference trajectory carried out by the expert.

B. Comparison to the reference gesture

A reference gesture is defined from expert trajectories. The comparison is based on the calculation of the error integral with respect to the reference gesture.

Figure 5 shows the evolution of the time needed by the residents to place the forceps as they wish. One notices that the residents manage, at the end of the training (placement 7, 8 and 9), to place the forceps in a constant time near to the reference which seems to mean that they control their gestures more and more and that their gestures become less hesitant. On this figure LFB corresponds to the Left Forceps Blade, RFB corresponds to the Right Forceps Blade, R1 (respectively R2 and R3) corresponds to the time needed by resident R1 (respectively R2 and R3) and RT corresponds to the reference time defined by the expert. For every operator, the LFB are plotted as a solid line and the RFB are plotted as a dashed line.

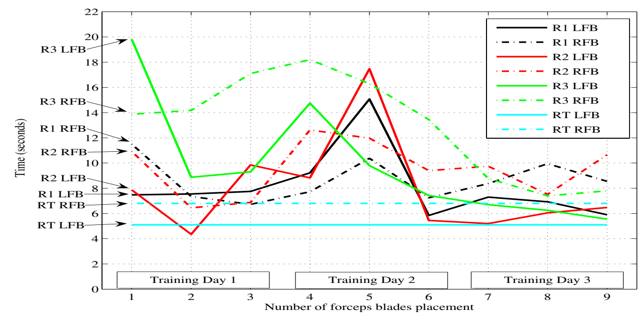


Fig. 5. Duration of the forceps blades placements

The error of the trajectories is compared to the reference one, the error along each axis is cumulated and only the sum ε is shown on table II.

Station and location OA+2	ε for R1		ε for R2		ε for R3	
Placement	Left blade	Right blade	Left blade	Right blade	Left blade	Right blade
1	33.45	21.47	27.33	48.31	49.25	32.94
2	17.57	27.71	29.48	36.94	14.86	32.80
3	19.03	24.18	36.27	18.08	22.80	49.20
4	23.18	15.70	21.65	25.26	43.13	54.01
5	15.44	22.07	66.55	20.53	25.14	47.98
6	12.79	16.76	16.58	22.08	20.09	18.21
7	14.50	22.94	13.68	28.20	22.47	21.69
8	14.30	21.42	14.93	18.82	20.50	22.07
9	21.98	20.35	9.15	38.21	25.82	27.06

TABLE II

ERROR ε FOR EACH RESIDENT COMPARED TO THE REFERENCE GESTURE

In this table, we notice a reduction of the global error ε for each resident before the training (placement 1, 2 et 3) and after the training (placement 7, 8 et 9).

Figure 6 gathers the results of table II and represents, as a histogram, the residents evolution according to the placement which they carry out. On this histogram, the black bars represent resident R1 forceps blades errors (left and right), the grey bars represent resident R2 forceps blades errors and finally the white bars represent resident R3 forceps blades errors.

An error ε reduction is noticeable which means that the trajectories of the residents tend "to be closer" to the reference trajectory defined by the expert.

IV. DISCUSSION

From the residents point of view, they appreciated to be trained on the BirthSIM simulator which allows them to avoid the constraints of the childbirth ward in order to learn

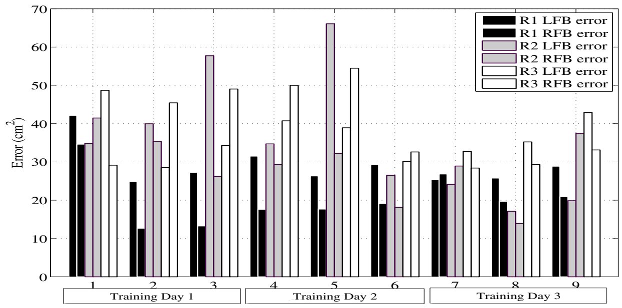


Fig. 6. Error during the forceps placements

the forceps blades placement. Indeed, while they are training on the simulator, they are not in an emergency situation so they could train without stress and risk of wounding the fetus or the mother. With the visualization interface, they could see the trajectory of the forceps around the fetal head inside the pelvis.

The constraints are also present for the instructor in a childbirth ward, thus the expert could explain with more time the forceps blades placement and by using the visualization interface of the simulator he could control the residents forceps trajectory inside the pelvis.

From the repeatability point of view, the dispersion of the residents gestures decreased on the whole. Certainly, for some gestures the values of the radii increased (radius of the starting sphere of the right blade for the three residents) but the starting point is much less crucial than the return and arrival points. They seem to have acquired a better repeatability and especially a surer gesture.

From the point of view of the comparison to the reference gesture, the trajectories have gotten closer to the reference. The error tends to decrease for all the residents. Once they acquired the correct obstetric gesture, they manage to serenely place the forceps with less hesitation.

To complete this study, a more complete study is necessary with a larger resident sample. This was not possible within the scope of this paper because there were not enough residents available at the hospital. One would need a study on several hospitals to make it more representative. Moreover, more measurements and a more significant follow-up of the residents are necessary to complete the study, unfortunately the residents are at the hospital only for a semester. However these first results are encouraging for the continuation of the research. They show that a simulator training is useful for the residents in the beginning stage of their experience before acting in a childbirth ward which is a necessary step in their degree course to become an obstetrician. Whatever their experience, first and third semester resident manage to increase their degree of repeatability and to decrease their errors compared to a reference gesture.

V. Conclusion

In conclusion, this paper shows the advantages of a training on a childbirth simulator provided with an instrumented forceps. The advantages of the simulator training are multiple at the same time for the patients (the risk reduction of the compulsory training period done on real patients), for teaching (pre- operational training, fundamental principles training, simulations of rare cases, individual and adaptable training, without constraints) and to experiment new techniques.

The analysis of a first clinical study shows that the gestures of the residents who have been trained on the simulator progressed and acquired a higher degree of repeatability in their gestures. Their gestures are less hesitant and they tend to get closer to a reference trajectory defined by an expert obstetrician. Criticisms of the residents and of the instructor enable the simulator to be adapted to their needs.

A new campaign of measurement should be launched soon with the use of the electropneumatic component so that the residents can train to extract the fetus once the forceps is correctly placed.

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