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Full lenght article

Operative and diagnostic hysteroscopy: A novel learning model combining new animal models and virtual reality simulation

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ABSTRACT

Context: Hysteroscopy is one of the most common gynaecological procedure. Training for diagnostic and operative hysteroscopy can be achieved through numerous previously described models like animal models or virtual reality simulation. We present our novel combined model associating virtual reality and bovine uteruses and bladders.
Study design: End year residents in obstetrics and gynaecology attended a full day workshop. The workshop was divided in theoretical courses from senior surgeons and hands-on training in operative hysteroscopy and virtual reality Essure® procedures using the EssureSim™ and Pelvicsim™ simulators with multiple scenarios. Theoretical and operative knowledge was evaluated before and after the workshop and General Points Averages (GPAs) were calculated and compared using a Student's T test.
Results: GPAs were significantly higher after the workshop was completed. The biggest difference was observed in operative knowledge (0,28 GPA before workshop versus 0,55 after workshop, $p < 0{,}05$). All of the 25 residents having completed the workshop applauded the realism an efficiency of this type of training. The force feedback allowed by the cattle uteruses gives the residents the possibility to manage thickness of resection as in real time surgery. Furthermore, the two-horned bovine uteruses allowed to reproduce septa resection in conditions close to human surgery
Conclusion: Teaching operative and diagnostic hysteroscopy is essential. Managing this training through a full day workshop using a combined animal model and virtual reality simulation is an efficient model not described before.

Introduction

Diagnostic and operative hysteroscopy is one of the most common surgical interventions in gynaecology, allowing for diagnosis and treatment of a wide range of pathologies [1,2]. In recent years, the technological advancements such as the use of small diameter (3,5 mm) rigid hysteroscopes combined with "no touch" techniques have made hysteroscopy a commonly accepted procedure [3,4]. Nevertheless, it is not painless [5,6] and it is not complications-free [7].

Moreover, acquisition of surgical skills is slowly shifting paradigms. Surgical hands-on education for trainees is going out of the operating rooms and into the classrooms . . . or simulation rooms. In recent years, simulation for surgical training, has taken centre stage in teaching young residents how to perform their first surgeries [8]. The French High Authority of Health (H.A.S) has issued guidelines concerning simulation for all fields of medical education. One of the main proposition is that medical training through simulation should be integrated in all learning programs for health professionals, the main goal being to "never perform a procedure for the first time on a real patient" [9]. Although there is no unequivocal proof of this type of learning vis-à-vis its cost effectiveness and decreased mortality and morbidity when confronted to traditional training [10,11], laparoscopic training models like boxes and simulators have proven that their effectiveness in limiting intervention time in trainees with no- or little- prior laparoscopic experience [10,11]. Also, a learning curve is necessary in simulation depending on the surgical procedure.

Different models have been explored for hysteroscopy training, ranging from butternut pumpkin resection [12], to animal models

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[13] such as pig bladder and cattle uterus [14]. Virtual simulators, like the Hystim™ simulator have also been used for teaching purposes [15].

For the last 2 years, our centre has proposed a hysteroscopic workshop based on a theoretical course followed by hands-on training on two animal models (bovine uteruses and bladders) and virtual reality simulation. Beyond the technical aspect of the procedure, it is fundamental for all surgeons to know how to handle the hardware available in the operating room and to manage eventual operative and post operative complications.

Our objective was to report our experience and to evaluate its impact on global operative knowledge and diagnostic and operative hysteroscopy performance in young trainees.

Methods

The workshop was developed for 4 consecutive years with the last 2 years using a bovine model. Uteruses and bladders were obtained from authorized abattoirs under the supervision of a certified veterinarian (Abattoirs de Douai, in accordance with French Bioethics laws). Prior to obtaining the organs, an authorization was issued from local authorities (Direction Départemental de la Protection des Personnes, Nord-France) allowing for the use of organs derived from cattle destined for human consumption for educational purposes.

Cattle uteruses are two-horned and present with long cervix [16]. The uterus horns are approximately 5 cm long and are separated by a septa. The cervix's length varies from 1,5 cm to 8 cm according to cow parity.

The uteruses were prepared as follow: the cervix was shortened to present with a maximum length of 2 cm, the fallopian tubes were obturated as to prevent irrigation fluid from escaping the cavity by going through them. The uteruses were fixed inside the box and only the cervix was made visible in order to reproduce real time surgery conditions (Figs. 1 and 2).

The bladders were prepared the same way (Fig. 3). Before simulation started all bladders were thoroughly checked, as the processing of this particular organ in abattoirs can be traumatizing for the bladder wall. Perforations in the bladder wall, when found, were sutured. The bladders where then prepared as to reproduce a cervical opening.

Fig. 1. The bovine uterus as it was disposed in a box.

Fig. 2. External view of the mounted resectoscopes and the protruding uterin cervix.

Two virtual reality simulation stations were made available for the trainees. All stations were animated by a senior surgeon and a certified European Training Expert from Bayer Healthcare®. One simulator was the VirtaMed PelvicSim™ (force feedback) and the other was the VirtaMed HystSim™ Fig. 4 (no force feedback). Both simulators allowed for training in multiple scenarios of Essure® placement.

Trainees were all obstetrics and gynaecology residents in their 5th and final year of residency at the Lille University Hospital (CHRU-Lille). The workshop was divided in two parts, all on the same day. The first part consisted in a 3-h interactive learning course with basic and advanced hysteroscopic techniques presented by senior surgeons. Teaching support were presentations and live-surgery videos encompassing a wide variety of operative hysteroscopy techniques. Prior to these courses, trainees were required to fill out a multiple choice form in order to evaluate their knowledge before and after the workshop. The trainees' general characteristics were also recorded.

The multiple choice evaluation was divided in three different parts. The first part explored the technical knowledge of the trainee (electrical settings, clinical indications and hardware setup). This part also explored how confident the trainees felt, prior to the workshop, when performing hysteroscopies. The second part evaluated operative knowledge (time of resection, fluid nature etc.). The third part aimed to evaluate management of operative and post operative complications (perforation, excessive fluid usage, contra indications . . .). Each question had a possible score ranging from 0 to 2. A general point average (GPA) was calculated for each part before and after the workshop. All the forms were anonymously filled out.

The second part of the workshop consisted in the hands-on simulation. It took place in the Research and Experimental Departement of Lille's medical university (DHURE-Lille). Trainees were divided in 4 workstations. Each workstation allowed for simulation of hysteroscopic resection, septum resection and endometrectomy on both uteruses and bladders. All the trainees had to perform at least one of each procedures. The Essure® simulation posts were made available. Every resident had a personal statistics chart from the VirtaMed PelvicSim™ and the VirtaMed HystSim™ simulators following their session.

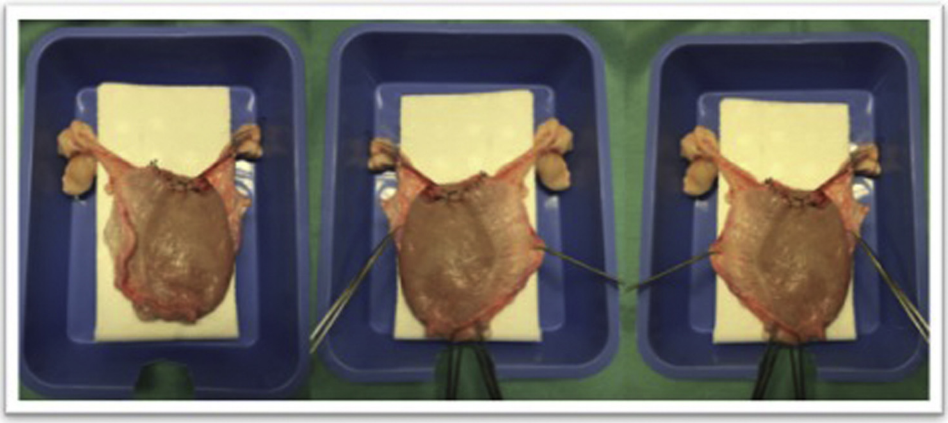

Fig. 3. Cattle bladder as they were arranged in the boxes.

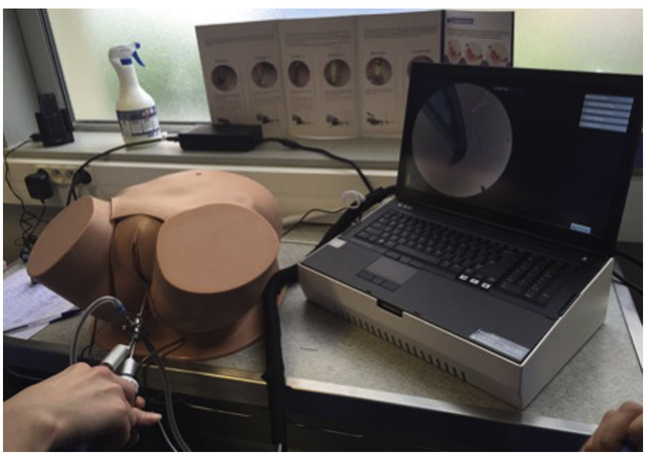

Fig. 4. The Hystim ™ simulator.

Pre and post workshop GPA's were compared using a Student's *t*-test (Microsoft Excel for Mac, version 15.19.1). P value was set at 0,05.

Results

25 Trainees attended the workshop. All of the participants, had spent at least 6 months in a university hospital's surgical gynaecology unit. 48% had already attended at least one extra simulation workshop dedicated to endoscopic surgery. Mean age of participants was 28,4 years (Median = 28 +/− 0,95 SD) Table 1 summarizes the general characteristics of the trainees and how they perceive their surgical dexterity and experience prior to the workshop. 68% of attendees didn't feel confident while performing an operative hysteroscopy and 60% of didn't thoroughly know the electrical presets before an operative hysteroscopy.

Pre and post-workshop theoretical knowledge

Post workshop GPA was higher than pre workshop GPA. Trainees fared better after having completed the whole session. All the differences between the pre and post workshop GPAs were statistically different using the student T test. The biggest observed difference between the GPAs concerned the technical knowledge part, especially when the multiple choice questions concerned the electrical settings and presents required to complete an operative hysteroscopy and the nature of the fluids. The GPA for operative knowledge was respectively 0,28 in pre test and 0,55 in post test. Complication management knowledge was respectively 0,46 and 0,7 (Table 2).

Overall feedback

Overall feedback was satisfactory. Trainees rated the first part of the workshop (introduction to basic surgical principles etc.) in average, 9.39 out of a possible 10 mark. The second part of the workshop, the hands-on training was rated, in average, as 13.8 out of a possible 15. All the bovine uteruses allowed for either septa resection, or endometrectomy. The bladder model was preferred to the uterine model concerning endometrectomy as the bovine uterus was too thick to reproduce *in vivo* situations. None of the sutured bladders ruptured during irrigation. Fig. 5 shows pre and post resection uterin cavity aspect.

Discussion

Diagnostic or operative hysteroscopy is one of the most common surgical intervention in gynaecological surgery. In recent years, it has acquired a central role in diagnosis and treatment of a variety of uterine pathologies like fibroids, polyps and uterine malformations [1,2,17]. It is also pivotal in the management of primary or secondary infertility [18]. We report an innovative training program combining theoretical courses and hands on training with animal models and virtual simulation for diagnostic and operative hysteroscopy. As the global feedback pointed out, the workshop was praised by the trainees. The most common feedback comment received was the perceived "reality" of the simulation. We also showed significantly higher GPA scores for all residents after the workshop was completed for all type of theoretical knowledge (technical, operative and complication knowledge).

All areas of surgical training are presently progressively integrating operative simulation as an indispensable part of the "learning curve". More generally all areas of medicine are presently encompassing simulation, where it be ultrasound training [19], gastrointestinal endoscopy [20] or ENT surgery [21]. The causes for this progressive switch are multiple and diverse. Simulation, if not already a fundamental part of the training curriculum for surgical residents, is to become pivotal in training future surgeon, as demonstrated by such programs as the Gynaecological endoscopic surgical education and assessment [22] diploma and the French Guidelines for Simulation for health professionals [9]. From a purely economical perspective, training residents bears a significant cost on Operating Room (OR) costs as recent studies have shown [23,24], both financially and on allocated operative time.

Table 1
General Caracteristics of the attendees.

	N = 25 (%)
Age (Years) (Mean;SD)	28,4; 0,95
Sex	
• Male	5 (20%)
• Female	20 (80%)
Extra workshop attendance	
• At least one	12 (48%)
• None	13 (52%)
Number of diagnostic hysteroscopies realized	
• <10	5 (20%)
• 10–20	2 (8%)
• 20–50	14 (56%)
• >50	4 (16%)
Number of operative hysteroscopy realized	
• <5	16 (64%)
• 5–10	8 (32%)
• 10–20	1 (4%)
• >20	0
Number of Essure® procedures realized	
• <5	10 (4%)
• 5–10	5 (20%)
• 10–20	8 (32%)
• >20	2 (8%)
Hysteroscopy hardware set-up	
• Confident	18 (72%)
• Not confident	7 (28%)
Hysteroscopic resection	
• Confident	8 (32%)
• Not confident	17 (68%)
Electrical power presets	
• Known	10 (4%)
• Unknown	15 (60%)

Furthermore, the European Working Time Directive (EWTD) limits the week to a 48 h of total "in hospital" work time [25]. While there are more factors implicated in the rise of simulation, these two aspects have modified the traditional "Halstedian" technique for surgical learning [26].

Our bovine model associating both cattle uteruses and bladders is new. Ewis and Khan [14] described a cattle uterine model for hysteroscopy, without the association of the bladder model (which has advantages not found in uteruses). When compared with virtual reality simulation, this workshop presented with multiple advantages. Firstly, using this bovine model allows for a force feedback allowing trainees to adapt the pressure they applied to the hysteroscopes while performing resections, thus allowing for a better control of the thickness of the endometrectomy, and a safer, smoother resection dynamic. Simulators do not allow for such a real time force feedback which is fundamental in mastering the finer details in hysteroscopic resections. The bovine bladder, while thicker than the human bladder, also allows for a finer control of the thickness resection as it is less thick than the bovine uterus. Also, the cow uterus being two horned it allowed for multiple resection types. For example, after having simulated endometrectomy, trainees were encouraged to simulate a synechia or septate uterus treatment by using a bipolar tip from one horn to the other. Using a real life bovine model with a saline irrigation also imposed a strict control of the fluid deficit balance, which is an overly important safety checkpoint while performing hysteroscopies as a fluid deficit above 2 L can lead to patient complications [27].

Moreover, our model is cheap and easy to reproduce in any teaching hospital. The uteruses and bladder are not used for human consumption, thus they can easily be obtained at any abattoir free of charge, whereas simulators are note ubiquitous in the ORs and access to quality teachings solely on virtual simulators is still not available for all trainees.

The Hystim® system allows for virtual reality training for diagnostic and operative hysteroscopy [15], and for Essure® implant placement [28] (using the EssureSim™). Training for this type of procedure is essential considering that traditional laparoscopy for tubal sterilization has been supplanted by the Essure® procedure. This procedure being faster, more cost effective and with less complications [29]. Lousquy et al. [30] demonstrated that without proper training, the Essure® procedure for tubal sterilization had a failure rate of over 10%. Whereas with proper training this failure rate dropped significantly, as did procedure duration. Janse et al. showed that the use of a virtual reality simulator in this indication allowed for novices to show significant progress after 9 repetitions [31]. Within our workshop trainees had the possibility to practise implant delivery using 2 virtual reality simulators (the EssureSim™ as described by Panel et al. [28] and the PelvicSim™ with force feedback). Thus, when combined with the animal model, this workshop allowed for training and perfection for a significant scope of hysteroscopic procedures.

Finally, we consider this workshop to be the closest reproduction of a real-life *in vivo* hysteroscopy associating animal model and virtual simulation. Our effort to establish this model is in compliance with recent recommendations of minimally invasive surgical organizations [32]. This workshop had a positive impact on residents. Their confidence in their surgical skills grew, as did their theoretical and operative knowledge.

Nevertheless, our experience is limited by a number of factors. Notably, the absence of objective evaluation of the training

Table 2
Comparison between pre and post workshop GPA.

	Pre-workshop GPA	Post-workshop GPA	P
Technical knowledge	0,39 (4,76/12)	0,84 (10,1/12)	<0,05
Operative knowledge	0,28 (1,68/6)	0,55 (3,32/6)	<0,05
Complication management knowledge	0,46 (3,68/8)	0,7 (5,64/8)	<0,05

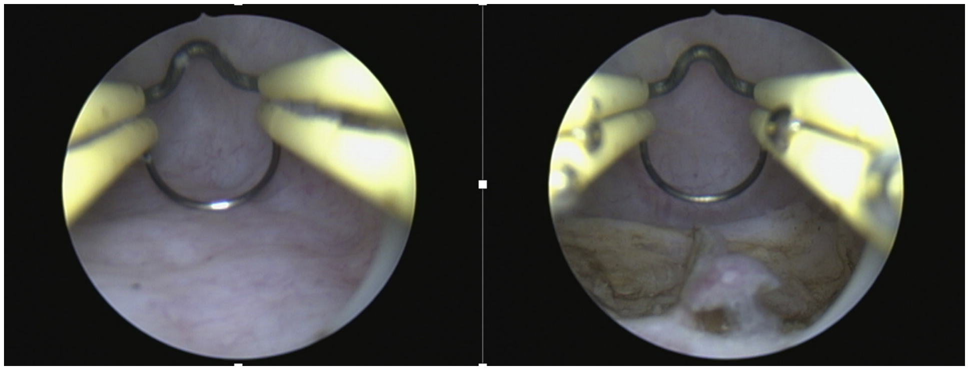

Fig. 5. Hysteroscopic tissue resection with the bladder bovine model.

sessions. We did not objectively evaluate the length needed for each trainee's complete resection simulation, or the total quantity of fluid usage, or grade their dexterity. Moreover, absence of bleeding while resecting, as it is one of the main factors that lead to the premature termination of the procedure in real life situation, if not managed during the intervention. Also, the bovine cervix being significantly wider than the human cervix, we could not show our trainees another main complications of operative hysteroscopies which are cervical false route and perforations while introducing the resectoscopes or while dilating the cervix. Difficulty with cervical entry account for 50% of complications during operative hysteroscopy [7,33]. No complication secondary to cervical entry was noted during the workshop. One of the other potentials limits is the lack of proven on-patient benefits of this type of training. An interesting aspect of these type of educational programs would be to evaluate their long term impact on public health policies and finances.

Conclusion

The bovine hysteroscopic simulation model is a realistic hands-on surgical training method that allows residents to practise complex hysteroscopic surgical interventions in a safe environment. Moreover, this model is easily reproducible and can be a valuable tool in allowing residents to initiate their learning curve. It can be associated with virtual simulation to learn how to perform tubal sterilization with implants, and also diagnostic and operative hysteroscopy. Also, this type of workshop, where it be in hysteroscopic surgery or laparoscopic surgery should be reiterated during early training years. Indeed, residents where overly enthusiastic vis-à-vis both the hands on experience and the "state of the art" knowledge that was presented in the first half of the workshop. This model can also be applied in urological surgery and gastro-intestinal endoscopy. Also, it could be an efficient tool to maintain and improve knowledge through continuous medical training.

Conflict of interest

Pr Rubod: Olympus and Nordic Pharma (Operative Demonstrations).

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References

[1] Gambadauro P, Martínez-Maestre MA, Torrejón R. When is see-and-treat hysteroscopic polypectomy successful? Eur J Obstet Gynecol Reprod Biol 2014;178:70–3.
[2] Di Spiezio Sardo A, Taylor A, Tsirkas P, Mastrogamvrakis G, Sharma M, Magos A. Hysteroscopy: a technique for all? Analysis of 5,000 outpatient hysteroscopies. Fertil Steril 2008;89(2):438–43.
[3] Bettocchi S, Nappi L, Ceci O, Selvaggi L. What does diagnostic hysteroscopy mean today? The role of the new techniques. Curr Opin Obstet Gynecol 2003;15(4):303–8.
[4] Mairos J, Di Martino P. Office Hysteroscopy An operative gold standard technique and an important contribution to Patient Safety. Gynecol Surg 2016;13:111–4.
[5] Cooper NaM, Smith P, Khan KS, Clark TJ. Does cervical preparation before outpatient hysteroscopy reduce women's pain experience? A systematic review. BJOG Int J Obstet Gynaecol 2011;118(11):1292–301.
[6] Gupta JK, Clark TJ, More S, Pattison H. Patient anxiety and experiences associated with an outpatient one-stop see and treat hysteroscopy clinic. Surg Endosc 2004;18(7):1099–104.
[7] Bradley LD. Complications in hysteroscopy: prevention, treatment and legal risk. Curr Opin Obstet Gynecol 2002;14(4):409–15.
[8] Gallagher AG, Ritter EM, Champion H, Higgins G, Fried MP, Moses G, et al. Virtual reality simulation for the operating room: proficiency-based training as a paradigm shift in surgical skills training. Ann Surg 2005;241(2):364–72.
[9] Haute Autorité de Santé Guide de bonne pratique en simulation santé. 2010.
[10] Gurusamy KS, Nagendran M, Toon CD, Davidson BR. Laparoscopic surgical box model training for surgical trainees with limited prior laparoscopic experience. Cochrane Database Syst Rev 2014(3) CD010478.
[11] Nagendran M, Toon CD, Davidson BR, Gurusamy KS. Laparoscopic surgical box model training for surgical trainees with no prior laparoscopic experience. Cochrane Database Syst Rev 2014 CD010479.
[12] Kingston A, Abbott J, Lenart M, Vancaillie T. Hysteroscopic training: the butternut pumpkin model. J Am Assoc Gynecol Laparosc 2004;11(2):256–61.
[13] Savran MM, Sørensen SMD, Konge L, Tolsgaard MG, Bjerrum F. Training and assessment of hysteroscopic skills: a systematic review. J Surg Educ 2016.
[14] Ewies AAA, Khan ZR. Cattle uterus a novel animal laboratory model for advanced hysteroscopic surgery training. Obstet Gynecol Int 2015;2015:967693.
[15] Neis F, Brucker S, Henes M, Taran FA, Hoffmann S, Wallwiener M, et al. Evaluation of the HystSim™-virtual reality trainer: an essential additional tool to train hysteroscopic skills outside the operation theater. Surg Endosc 2016;2016.
[16] Warnick A., Anatomy and Endocrinology of Cow Reproduction. FAO2015.
[17] Capmas P, Pourcelot A-G, Giral E, Fedida D, Fernandez H. Office hysteroscopy: a report of 2402 cases. J Gynécologie Obstétrique Biol Reprod 2016;45(5):445–50.
[18] Lorusso F, Ceci O, Bettocchi S, Lamanna G, Costantino A, Serrati G, et al. Office hysteroscopy in an in vitro fertilization program. Gynecol Endocrinol Off J Int Soc Gynecol Endocrinol 2008;24(8):465–9.
[19] Nanda NC, Kapur KK, Kapoor PM. Simulation for transthoracic echocardiography of aortic valve. Ann Card Anaesth 2016;19(3):498–504.
[20] van der Wiel SE, Küttner Magalhães R, Rocha Gonçalves CR, Dinis-Ribeiro M, Bruno MJ, Koch AD. Simulator training in gastrointestinal endoscopy – from basic training to advanced endoscopic procedures. Best Pract Res Clin Gastroenterol 2016;30(3):375–87.
[21] Piromchai P, Avery A, Laopaiboon M, Kennedy G, O'Leary S. Virtual reality training for improving the skills needed for performing surgery of the ear, nose or throat. Cochrane Database Syst Rev 2015(9) CD010198.
[22] Campo R, Wattiez A, Tanos V, Di Spiezio Sardo A, Grimbizis G, Wallwiener D, et al. Gynaecological endoscopic surgical education and assessment. A diploma programme in gynaecological endoscopic surgery. Gynecol Surg 2016;13:133–7.

[23] Maqsood H, Buddensick TJ, Patel K, Ferdosi H, Sautter A, Setiawan L, et al. Effect of residents on operative time and complications: focus on laparoscopic cholecystectomy in the community. J Surg Educ 2016;73(5):836–43.
[24] Allen RW, Pruitt M, Taaffe KM. Effect of resident involvement on operative time and operating room staffing costs. J Surg Educ 2016.
[25] Fitzgerald JEF, Caesar BC. The European Working Time Directive: a practical review for surgical trainees. Int J Surg Lond Engl 2012;10(8):399–403.
[26] Barnes RW, Lang NP, Whiteside MF. Halstedian technique revisited. Innovations in teaching surgical skills. Ann Surg 1989;210(1):118–21.
[27] American College of Obstetricians and. Gynecologists technology assessment no. 7: hysteroscopy. Obstet Gynecol 2011;117(6):1486–91.
[28] Panel P, Bajka M, Le Tohic A, Ghoneimi AE, Chis C, Cotin S. Hysteroscopic placement of tubal sterilization implants: virtual reality simulator training. Surg Endosc 2012;26(7):1986–96.
[29] Litta P, Cosmi E, Sacco G, Saccardi C, Ciavattini A, Ambrosini G. Hysteroscopic permanent tubal sterilization using a nitinol-dacron intratubal device without anaesthesia in the outpatient setting: procedure feasibility and effectiveness. Hum Reprod Oxf Engl 2005;20(12):3419–22.
[30] Lousquy R, Friederich L, Le Tohic A, Grosdemouge I, Renouvel F, Gairin F, et al. État des lieux de la formation des chirurgiens gynécologues à l'hystéroscopie en France et en Europe. Enquête CONFORM sur la formation à la mise en place des implants de stérilisation tubaire par voie transcervicale. Gynécol Obstétrique Fertil 2009;37(9):691–6.
[31] Janse JA, Goedegebuure RSA, Veersema S, Broekmans FJM, Schreuder HWR. Hysteroscopic sterilization using a virtual reality simulator: assessment of learning curve. J Minim Invasive Gynecol 2013;20(6):775–82.
[32] ESGE, EAGS, ACOG, ENTOG, ACOG, AAGL, Joint recommendation on endoscopic training. ESGE Homepage 2014.
[33] Al-Fozan H, Firwana B, Al Kadri H, Hassan S, Tulandi T. Preoperative ripening of the cervix before operative hysteroscopy. Cochrane Database Syst Rev 2015(4) CD005998.