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Review

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Laparoscopic box simulators constitute an accessible, affordable and effective solution for training in laparoscopic surgery

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Abstract

Background: Acquisition of laparoscopic surgical skills is best achieved before entering the operating theatre, in the context of a simulated environment. Although mechanical simulators are affordable and effective training tools, they remain non available in many training institutions. This study investigates the options available and the cost for purchasing a mechanical laparoscopic simulator and developing a training laboratory.

Material and Methods: A search strategy was developed for PubMed, YouTube and Google search engines, using the relevant keywords for studies reporting on commercially available and homemade laparoscopic mechanical simulators (laparoscopic box trainers), in order to assess the cost, availability and effectiveness of such constructions.

Results: Laparoscopic box training systems were found to be readily available to purchase on the internet at a surprisingly low cost that ranged from 260€ for simple box trainers attachable to a home computer or a tablet, up to 6,600€ for a complete training tower with screen, full range of instruments and training software. Instructions for "do - it - yourself" simulators at no cost are available in both internet and medical literature. Such devices have been adequately validated and have been proven to be effective training tools.

Conclusion: Mechanical simulators for training laparoscopic surgical skills are widely available, affordable, and effective. They can be easily incorporated in any training program and allow trainees to achieve and maintain laparoscopic dexterities and to simulate simple surgical procedures. Training institutions can invest in a training laboratory that would supplement their academic and clinical training curriculum. Most importantly, trainees can tailor their own training by having their personal laparoscopic box trainer.

Keywords: laparoscopy; box trainer; simulator; training; surgery

Training in laparoscopic surgery is challenging, even when resources are readily available[1,2]. The opportunities trainees have to participate in laparoscopic procedures are often limited. Ideally trainees should have secured most of the theoretical knowledge and the practical skills before enter-

ing the operating theatre[2,3]. Theoretical training is accessible through textbooks, courses, videos, live operations and mentoring. The use of laparoscopic tools needs practice on simulators and models that are often difficult to access and pricey. Indeed, the cost of an electronic virtual reality simulator may be prohibitive[4]. There are, however, many simple mechanical simulators (laparoscopic box trainers) that can cover the basic educational needs at a very low cost. They have been adequately validated and their effectiveness in acquiring basic laparoscopic skills has been found comparable to that of electronic simulators or traditional training[2,3]. It is becoming apparent that mechanical simulators are a valuable training tool, and should be incorporated in the training curricula[1]. Yet, they are still not widely available in the training institutions, possibly because their validity, effectiveness and availability are not widely publicized. This study investigates the options available and the cost for purchasing a mechanical laparoscopic simulator, as well as the effect it could have on the training of junior surgeons.

Material and Methods

A market research was performed on the Internet, searching for commercially available mechanical laparoscopic simulators. The search engine used was Google with keywords: "buy, laparoscopic, simulator, box trainer". Given that the search was exploratory on availability and cost of box trainers, rather than systematic and exhaustive comparison of the available simulators, the search was limited to the first five pages that came up. In the same concept, a search was performed on YouTube using as key word: "laparoscopic box trainer", searching for videos giving instructions for building improvised box trainers and performing training exercises. Data on the validity and the effectiveness of mechanical simulators for developing laparoscopic skills were found in the Pubmed. The search was accomplished in January 2015.

Results

Google search brought up in the first pages a plurality of commercially available box trainers, with prices ranging from 225£ for a rather minimal set, up to 7,600$ for a full tower with wheels, screen, camera, full range of instruments, models and sophisticated software (Table 1). The low range products included a plastic box with a web camera that can be connected to a computer (not included) and the basic laparoscopic instruments (two forceps and a pair of scissors). There were similarly simple constructions that can be used with tablet computers, as well. At a higher cost, but still near 1,000€, one could get a set that includes more instruments, such as needle - holders, as well as training models for practicing. The cost was higher when the set included movable laparoscopic camera, screen, wheel - tower, more training models, and/or software for recording and analyzing the training course.

All mechanical simulators were based on the same principle. There was a box mimicking the peritoneal cavity, a camera overlooking in the box and transmitting the image to a display, laparoscopic tools that inserted the box through holes and models for practicing within the box. In "do - it - yourself" (DIY) constructions, a plastic carton was usually used with a size similar to that of the peritoneal cavity. Holes were made on it for entering the tools and attaching the camera and the light source. If the box was translucent or allowed the natural light in, a light source was unnecessary. The camera could be a web camera connected to a computer via a Universal Serial Bus (USB) port or the camera of a tablet computer using its own screen. Laparoscopic tools could be either purchased as new, or sterilized after using disposable single - use instruments, at no cost. Searching YouTube and Pub Med[5-8], one can easily find instructions on how to make improvised educational boxes. There are instructions for simple educational templates and exercises as well. The total cost of a DIY laparoscopic box trainer (provided that a computer is available) can be kept under 100€[9]. For the basic laparoscopic training, two laparoscopic forceps and one pair of scissors are required. Needle - holders should ideally be available for practicing laparoscopic suturing, but forceps can be used just as well. Improvised "home - made" models, or

Table 1. List of commercially available mechanical laparoscopic simulators that appear on the first five pages when Google is searched using the key words "laparoscopic, simulator, buy, box trainer" (January 2015)

Name of simulator	Price	Camera	For laptop	For tablet	Pairs of forcops	Pairs of scissors	Needle-holders	Monitor	Trolley	Web address
eoStudent Sim	249£	–	–	✓	2	–	–	–	–	www.eosurgical.com
eoSim Start	499£	USB	✓	✓	2	1	–	–	–	www.eosurgical.com
eoSimPro Track	998£	USB	✓	✓	2	1	2	–	–	www.eosurgical.com
eoSim Elite	3,198£	USB	✓	✓	2	1	2	Laptop	✓	www.eosurgical.com
Folding suture trainer	330$	–	–	–	–	–	–	Mirror	–	www.simulab.com
LapTrainer with SimuVision	1,921$	External	✓	✓	–	–	–	–	–	www.simulab.com
i - Pixus	225£	–	–	✓	2	–	–	–	–	www.inovus.com
Pixus HD	246£	USB	✓	✓	2	–	–	–	–	www.inovus.com
Pixus Pro Glide	1,500£	USB	–	–	2	–	–	✓	✓	www.inovus.com
LT LAP TAB TRAINER	368$	–	–	✓	–	–	–	–	–	www.3-dmed.com
(MITS) T3 Classic	2,305$	USB	–	–	–	–	–	✓	–	www.3-dmed.com
All - in - one FLS trainer system	7,600$	USB	–	–	3	1	2	✓	–	www.vtimedical.com
FLS trainer system	1,848$	USB	✓	✓	–	–	–	–	–	www.vtimedical.com
iSim2	–	External	–	–	–	–	–	✓	–	www.isurgical.com
Ergo - Lap	–	USB	✓	✓	–	–	–	–	–	www.io.tudelft.nl

"ready - made" ones purchased from the Internet, can be used for practice.

Concerning the training procedure, the trainee is asked to capture objects, transfer them, and generally move them using at first the dominant hand, then the non dominant and finally, passing them from one hand to the other. For example, one can pile sugar cubes, place hoops on a peg, allow objects to fall in a box from a height, pass a string through successive holes, or move from one end of the string to the other. The objective is to get the sense of three - dimensions through a two - dimensional image and to coordinate hand movements accurately. In order to get familiarized with the scissors, the trainee is asked to cut a circle or other shapes predesigned on paper or gauge. At a second stage, one can proceed to simulate surgical tasks, to place sutures using needle holders or forceps, and to tie knots. There are numerous literature reports on such training tasks[10], while YouTube is, once again, an invaluable source of training material.

The course of training can be monitored by timing the tasks and by counting mistakes, such as dropping the objects, crossing hands, or missing the target. There are several training curricula for practicing, as well as monitoring progress[11]. McGill Inanimate System for Training and Evaluation of Laparoscopic Skills (MISTELS) and Global Operative Assessment of Laparoscopic Skills (GOALS) were developed to assess laparoscopic skills and to score them objectively and are widely used[12]. Fundamentals of Laparoscopic Surgery (FLS) is a comprehensive web - based education module for developing and evaluating minimally invasive surgical skills. The training can take place in a training laboratory or at home and training can be monitored and assessed by the mentor or the trainee, provided that a structured program is followed and specific assessment tools are used.

Discussion

Our search has shown that mechanical laparoscopic simulators (box trainers) are widely available, accessible and affordable. At a very reasonable cost any hospital can invest in a training station, and any trainee can purchase or make a box trainer. One does not have to look any further than in the first pages of Google in order to buy a training set at a very reasonable price. If this is still out of range, one can have a DIY box trainer at minimal cost, using materials readily available in the market and basic craftsmanship. Therefore, availability or economic cost cannot stand as an excuse for lack of training in the use of laparoscopic instruments, neither for trainers, nor for trainees.

Laparoscopic box trainers have been the focus of intense research over the last decade and there have been several publications that support the construct validity and effectiveness of commercially available kits[13 - 20] and DIY constructions[9,21 - 27]. There is no doubt that such systems improve technical skills compared with no training in trainees without previous laparoscopic experience. Notably, there appears to be no significant difference in the improvement of technical skills when different box trainers are used[28]. Young trainees who are trained on simulators, can achieve basic laparoscopic skills that are comparable to those achieved after traditional training in the operating room, and perform live laparoscopies faster and better than residents who trained via standard clinical surgical education[29 - 32]. A meta - analysis of 18 studies showed that novices who were trained on simulators developed considerably better laparoscopic suturing and knot tying skills, conducted fewer errors, retained more knowledge than their respective control groups, and were significantly faster on time to completion[33]. Moreover, simulator training can help to maintain laparoscopic suturing skills, with suggested maintenance training interval of just one month on simple box trainers[34]. Simulated training improves the operating performance, shortens operating times and consequently, reduces both training time and cost[4,30,31]. As simulators provide better laparoscopic skills training than the traditional standard apprenticeship approach, many authors strongly encourage surgical residency programs to adopt the use of simulators in teaching laparoscopic surgery skills to novices be-

fore embarking on actual laparoscopic surgical procedures[33 - 36].

It is common, especially among novices, to consider high - tec and high - cost virtual reality simulators preferable to humble mechanical box trainers[10]. Furthermore, as stated in a recent update of a Cochrane review, "virtual reality training appears to decrease the operating time and improve the operative performance of surgical trainees with limited laparoscopic experience when compared with no training or with box - trainer training"[37]. Contrastingly, the same authors also stated that "the impact of this decreased operating time and improvement in operative performance on patients and healthcare funders in terms of improved outcomes or decreased costs is not known". Other studies suggest that both electronic and mechanical simulators improve trainees' performance with comparable effectiveness[12,29,32,38 - 41]. The maintenance of laparoscopic skills on the long term is also comparable when box trainers or virtual reality simulators are used[42]. A randomized controlled trial comparing training on either a virtual reality simulator or a box trainer concluded that they both significantly decreased the learning curve necessary to learn laparoscopic suturing, with the former being more efficient training modality, and the latter more cost - effective option[4]. While virtual reality trainers may have some advantages, especially in monitoring and assessing progress and simulating complex tasks, box trainers are comparably effective, rather popular and unbeatably cheap[4,10,43].

Taken together, we believe that the traditional training approach based on first observing and then assisting and performing in the operating theatre, needs to be updated, incorporating box trainers and/or virtual reality simulators. The development of innovative training methods, integrating simulators, seems to be the way forward[12]. Portable box trainers are useful and can effectively supplement a laboratory - based surgical simulation curriculum. However, personal possession of a portable simulator does not necessarily result in voluntarily long - term practice. When trainees were provided with personal box trainer, as well as access to surgical simulation lab, half of them found the trainer useful, but the other half thought it was not useful or did not access it anyway[44]. In fact, although all trainees reported that autonomous home practice on a laparoscopic box trainer is valuable[2,45], most of them claimed lack of training time outside work and preferred to practice during working hours[2]. Autonomous training could be encouraged and compliance improved by following structured training programs, with specific goals, adequate feedback points, and subsequent obligatory assessments[2]. There are frameworks for integrating simulation training into comprehensive training curricula. They highlight effective provision of feedback, deliberate practice, varying levels of training difficulty, and inclusion of both cognitive teaching and hands - on training as critical aspects of simulation training[1].

Conclusion

Acquisition of laparoscopic surgical psychomotor skills is best achieved before entering the operating theatre, in the context of a simulated environment. Our search came to the conclusion that mechanical simulators for training laparoscopic surgical skills are widely available, affordable, and effective. They can easily be incorporated in any training program and allow trainees to achieve significant laparoscopic skills, to maintain them, and even to simulate simple surgical procedures. Training institutions can invest in a training laboratory that would supplement their academic and clinical training curriculum. Most importantly, trainees can tailor their own training by having their personal laparoscopic box trainer.

Conflict of interest

All authors declare no conflict of interest.

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