Electronic device for endosurgical skills training (EDEST): study of reliability

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Abstract

Purpose Minimally Invasive Surgery procedures are commonly used in many surgical practices, but surgeons need specific training models and devices due to its difficulty and complexity. In this paper, an innovative electronic device for endosurgical skills training (EDEST) is presented. A study on reliability for this device was performed.

Method Different electronic components were used to compose this new training device. The EDEST was focused on two basic laparoscopic tasks: triangulation and coordination manoeuvres. A configuration and statistical software was developed to complement the functionality of the device. A calibration method was used to assure the proper work of the device. A total of 35 subjects (8 experts and 27 novices) were used to check the reliability of the system using the MTBF analysis.

Results Configuration values for triangulation and coordination exercises were calculated as 0.5 s limit threshold and 800–11,000 lux range of light intensity, respectively. Zero errors in 1,050 executions (0%) for triangulation and 21 errors in 5,670 executions (0.37%) for coordination were obtained. A MTBF of 2.97 h was obtained.

Conclusions The results show that the reliability of the EDEST device is acceptable when used under previously defined light conditions. These results along with previous work could demonstrate that the EDEST device can help surgeons during first training stages.

Keywords Electronic device · Minimally invasive surgery · Surgical assessment · Skills training

Background

Minimally Invasive Surgery (MIS) procedures are commonly used in many surgical practices. Laparoscopy is one of the disciplines that has become a gold standard technique in several of such procedures, although they need specific training models and devices [1,2]. Laparoscopic surgery has some associated problems such as the lack of tactile perception, movement coordination or adaptation to the two-dimensional image. These problems should be resolved during the first training stage [1]. Usually, specialized postgraduate courses are carried out by surgeons to solve these problems, but objective assessment tools are not available in all of them. Currently, these objective assessment criteria are the subject of numerous studies.
The Fundamentals of Laparoscopic Surgery (FLS) has been created by SAGES to regulate the laparoscopic training [2–4]. This education module includes the cognitive, decision-making and surgical skills tests. The McGill Inanimate System for Training and Evaluation of Laparoscopic Skills (MISTELS) program [5,6] was used and customized for the FLS program. The Objective Structured Clinical Examination (OSCE) technique is another commonly used method for measuring surgical skills [7]. The clinician is examined in a series of short station (5–10 min) by impartial examiners. The Objective Structured Assessment of Technical Skills (OSATS) is a usual one too [8–10].

An operator usually is needed for the application of the techniques described above, although some efforts have been made to automate them. An electromagnetic tracker has been used to develop the Imperial College Surgical Assessment Device (ICSAD) [11–14] and significant results have been obtained in different disciplines [15–20].

Other medical disciplines such as nursing or anaesthesia have devices equipped with highly accurate sensors. These human patient simulators (HPS) are widely used in training and some well-known examples are SimMan by Laerdal [21] or iStan by METI [22]. They are fully computerized simulation mannequins with high fidelity in the physiological behaviour of the human body. Anaesthesia practice [23], radiology resident evaluation [24], nursing education [25] and CPR training [26] among others are common applications of the HPS.

Laparoscopy is often used for other training devices such as pelvic trainers or virtual reality simulators. Although in recent years the use of the computer-enhanced technologies are higher regarded than the ones based on virtual reality among surgeons and medical students [27,28]. There are some accepted and validated hybrid systems of which ProMIS [29], LTS3e [30], CELTS [31] and Red Dragon [32,33] are the most important ones. Augmented and virtual reality are used by the ProMIS simulator to deliver optimum learning and feedback. It comprises different modules: basic skills, laparoscopic colectomy [34] and FLS [35]. Even a junior version (ProMIS-J) has been developed to promote the practice only. The LTS3e self-container simulator uses a structured testing and training of skills. It combines a carousel of physical reality tasks with computerized assessment using validated MISTELS metric [36]. An embedded metric algorithm is used by the CELTS prototype to automatically score the basic surgical skills [37]. Force and torque measure is an important feature added in the Red Dragon simulator [38]. Several modalities such as using animal models or physical and virtual simulation are also possible. The Red Dragon will be marketed by Simulab Corporation with the name of ‘the Edge’. Recently, Botden and Jakimowicz [39] have performed a review of all the augmented reality simulators described earlier.

Some recent developments are presented by Noh et al. [40] and Solis et al. [41] where different sensors are used to assess airway management and suture skills respectively. As far as we know, current training systems do not allow training and objective assessment of the triangulation manoeuvre. This work attempts to solve this need.

A major challenge of training systems is to demonstrate its impact on the learning curve. To achieve this, some interesting studies on this regard have been conducted with no conclusive results [42–44]. Additional studies have been developed to analyse the transfer of skills to the Operating Room [45,46]. These studies show that skills transfer occurs in some surgical procedures but not for all analysed concepts.

Reliability and validity tests are performed to demonstrate the utility of any training system [47–49]. These tests are performed to demonstrate that the system is ‘consistent in its measurements’ (reliability) and ‘acceptable in its operation’ (validity) [50]. In our experience, a further step may be necessary to achieve greater acceptance of virtual and hybrid systems by surgeons. An estimate of the simulator failures (reliability engineering) is needed to ensure the smooth running of them. The IEEE defines reliability as the ability of a system or component to perform its required functions under stated conditions for a specific period of time [51]. This study has been focused on this kind of reliability.

In this paper, a reliability engineering study for the electronic device for endosurgical skill training (EDEST) is presented. A review of its features, advantages and drawbacks are exposed, and finally, some future works and improvements are introduced.

Material and methods

In this section, an electronic device for endosurgical skills training (EDEST) is presented. The EDEST system can measure the total time and fully executed tasks of two basic laparoscopic training procedures: triangulation (one-point coordination) and coordination (grasping and moving) manoeuvres.

EDEST device functions

The EDEST® electronic device includes two tasks for laparoscopic basic training: triangulation and coordination manoeuvres. The first one uses two infrared leds in order to detect the correct coming together of both tooltips at the same time and to the same point. The second exercise is based on covering sockets with chickpeas, beans or drawing pins. These sockets are equipped with light-dependent resistors (LDR) that check the total time and the fully finished task. The system has an standard calibration (“Device and equipments”) in order to assure the correct luminosity setting of sensors.