Development and evaluation of an experimental setup with automated error analysis in laparoscopic and robotic surgery

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Introduction

General surgery highly demands for laparoscopic and robotic training. The objective assessment and automated measurement of trainee´s performance parameters are of didactic, scientific and economic interest. The aim was to create a standardised training environment for prospective assessment of minimally invasive procedures and instruments. Our working group developed a new automated modular box trainer. This standardised experimental setup underwent a first evaluation measuring performance time and error rates of two subject groups working on five typical basic task modules.

Methods

The box trainer (Fig. 2) consists of a base plate and a cover. The base plate carries an electronic housing and four magnetic task module holders (Fig. 3). The cover holds a maximum of four trocar cannulas. A novel pan-tilt laparoscope holder allows standardised image presentation (Fig. 1). The five tasks including basic skills of laparoscopic surgery (depth perception, hand-eye coordination and bimanual manipulation) were arranged by rising level of difficulty. The automated error detection is realised by shortcutting an electric circuit. The performance data were automatically recorded on SD card. These were analysed and correlated with the data of a post-test questionnaire. A pilot study was carried out with two groups, surgeons versus non-medical students, repeating the sequence of five tasks (Fig. 6) with laparoscopic instruments.

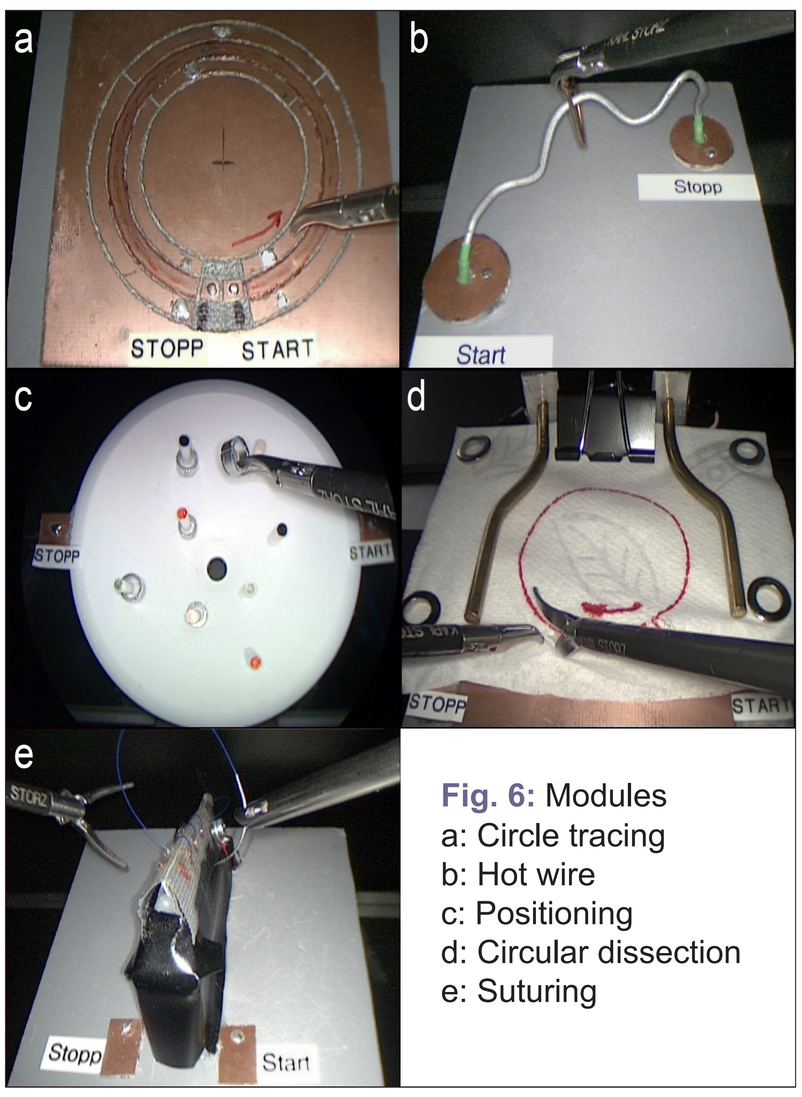

Fig. 6: Modules
a: Circle tracing
b: Hot wire
c: Positioning
d: Circular dissection
e: Suturing

Results

Differences between surgeons and non-medical students were most prominent in the task modules Hot wire (Fig. 4, 6b) and Circular dissection (Fig. 6d). The surgeons showed decreasing error rates during the repetitions in four of five tasks. In contrast, the non-medical students were only able to reduce their error numbers in two tasks. All subjects needed less performance time with increasing repetition number. The questionnaire survey showed that study subjects appreciated the training and declared a significant gain of practical competences. Most subjects assessed the transferability of the acquired skills into the operating theatre as „high“.

Conclusion / Outlook

The automated box trainer is suitable for laparoscopic training and performance recording of trainees. The pilot study indicates that the medical and professional background might be an important impact factor to the results. The further implementation of visual or audible feedback is planned. New modules are under development, one of them including a three-axis sensor measuring tissue manipulation forces. The evaluation of robotic systems (Da Vinci versus FLEXMIN, Fig. 5) will be the next step.

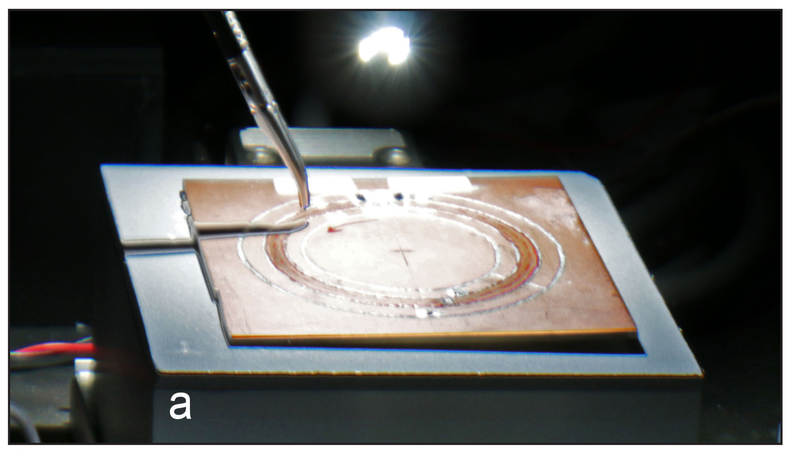

Fig. 1: Image presentation

Fig. 2: Box trainer

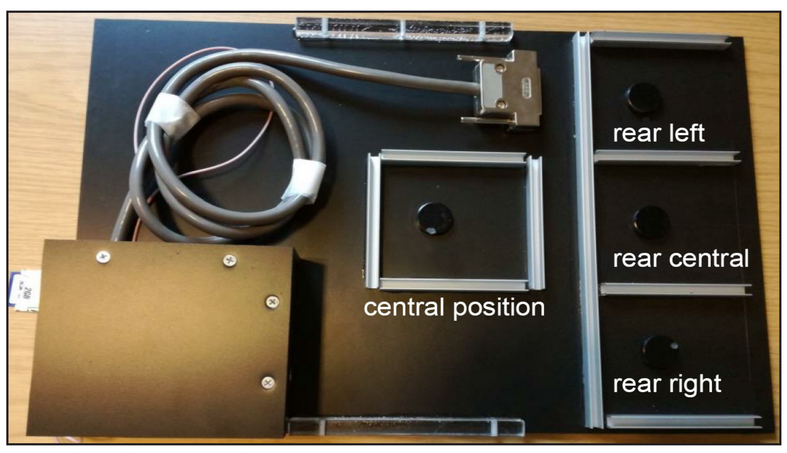

Fig. 3: Base plate

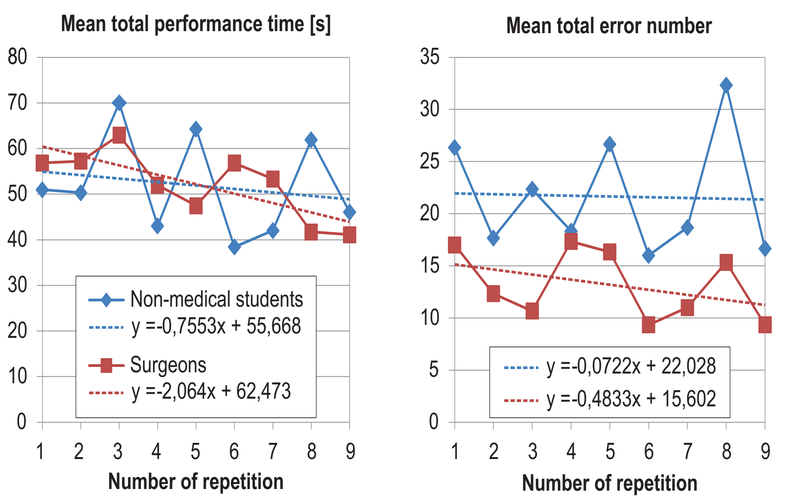

Fig. 4: Performance time and error number in task Hot wire

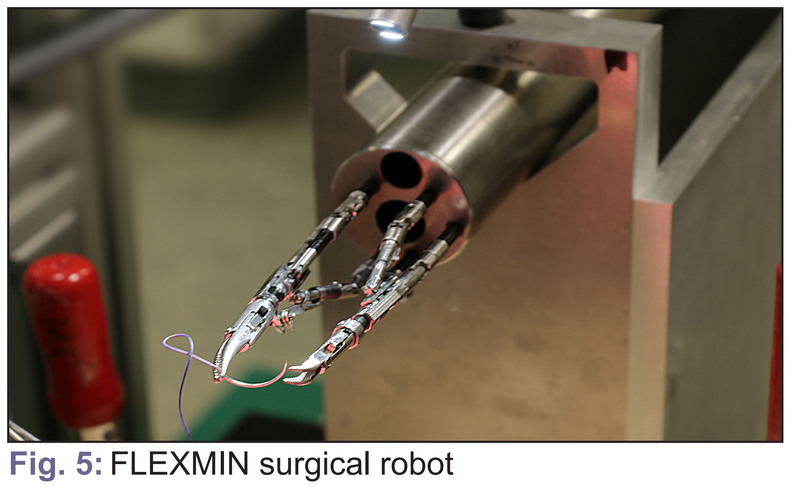

Fig. 5: FLEXMIN surgical robot

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