TRAINING AND PERFORMANCE OF ROBOTIC LAPAROSCOPY: ELECTROMYOGRAPHIC ANALYSIS TO QUANTIFY THE EXTENT OF PROFICIENCY

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INTRODUCTION

In recent years robot-assisted laparoscopy has been developed as a novel surgical procedure [1]. Although this technology promises ease of use and mechanical precision, little has been known about the learning strategies of this new technique [2, 4]. Evaluation of surgical performance and skill acquisition during training are limited in measuring only task completion time and number of errors occurred or a subjective evaluation by an expert [3]. To our knowledge, no studies have examined physiological measures (i.e. electromyography profiles) of the surgeons during performance of robotic surgical techniques. The purpose of this study was to assess changes in robot-based surgical performance through a designed training protocol using electromyography (EMG) in order to identify objective variables for the quantification of learning and dexterity.

METHODS

Seven right-handed medical students, novice users of the da Vinci® robotic surgical system, practiced three inanimate surgical tasks, bimanual carrying (BC), needle passing (NP) and suture tying (ST), with the robotic system for a total of six training sessions during a three weeks period. Before and after the training protocol, performance tests were conducted for all the tasks and muscular activation was monitored from the subject's right arm and forearm using a surface EMG system (DelSys; 1000 Hz). The muscles examined were: flexor carpi radialis (FCR), extensor digitorum (ED), biceps brachii (BB), and triceps brachii (TB). The relative EMG data, percent of raw EMG data relative to maximal EMG output (MVC), for each muscle and for each task were integrated for the entire task completion time (T) to obtain the total volume of muscular activation (EMGV). Moreover, the rate of muscular activation (EMGR) was calculated by dividing the EMGV by T. Mean values of the EMGV and EMGR were compared pre- and post-training using dependent *t*-tests (α=0.05).

RESULTS AND DISCUSSION

The results revealed significant reductions in EMGV for all muscles in all three tasks; except for the FCR muscle in the BC and ST tasks (Figure 1). However, reductions in EMGV were observed even for the FCR (Figure 1). The relative decreases in EMGV between pre- and post-training testing ranged from 33.2% to 68.6%. These results indicated that less motor units were recruited to perform the same tasks after training which can probably result in decreased fatigue. Significant increases in the EMGR were found for the FCR and TB muscles in all three tasks and for the ED muscle in the ST task (Figure 2). The relative increases in the EMGR in the muscles examined ranged from 30.3% to 84.5%. The EMGR results indicated improvements in the way that motor units are recruited and probably superior efficiency.

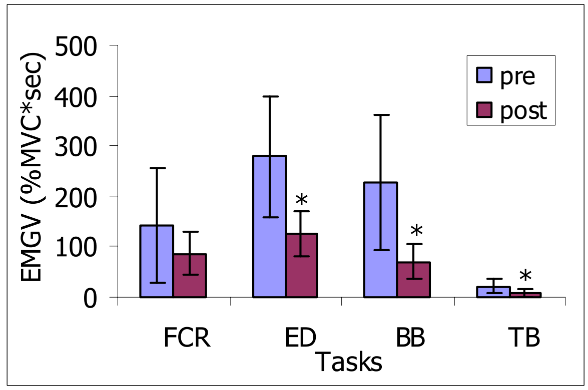

Figure 1: The total volume of muscular activation in the suture tying task (*$p \leq 0.05$).

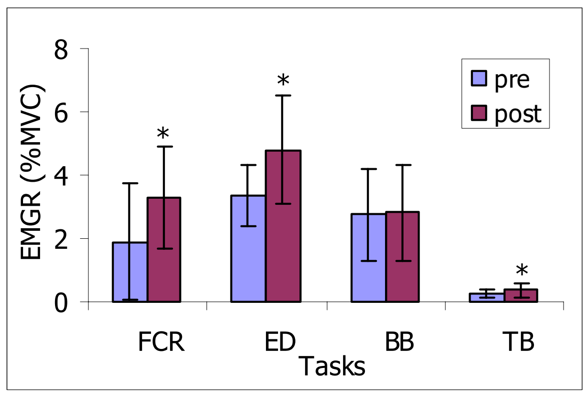

Figure 2: The rate of muscular activation in the suture tying task (*$p \leq 0.05$).

This study objectively demonstrated changes in robotic surgical performance in novice users through a designed training protocol using EMG profiles. The variables examined showed great promise as indicators of learning and dexterity for practical surgical tasks. Future studies will further validate these findings, as well as, incorporate the variables identified to establish valid criteria for the development of integrative surgical systems and virtual training tools.

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