

Postural control during laparoscopic surgical tasks

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Abstract

Background: Balance control during standing is essential while performing surgery. The postural sway must be controlled to enhance movement accuracy. Postural control was compared between novices and experts during standardized laparoscopic tasks.

Methods: Seven novices with limited exposition to laparoscopy were compared with 7 expert surgeons. The subjects were requested to perform 4 laparoscopic tasks on the McGill Inanimate System for Training and Evaluation of Laparoscopic Skills (MISTELS) and a quiet standing task while standing on 2 force platforms. An analysis of variance (ANOVA) with repeated measures was performed to compare groups and the different conditions. Significant level was set at $P < .05$.

Results: The technical requirements of the laparoscopic tasks impacted on postural sway in both antero-posterior and mediolateral directions. Furthermore, results indicate that the experts have a significantly better postural balance for all tasks compared to novices.

Conclusion: Postural sway increases with the technical requirements of minimally invasive surgery. This study showed that postural control performance while standing improves with laparoscopic expertise. © 2007 Excerpta Medica Inc. All rights reserved.

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Upright standing is the posture most commonly adopted in everyday living and the majority of surgical tasks are performed in this position. Most surgical procedures would ideally require the surgeons' posture to be completely static, but such nonmovement has been shown to be impossible [1]. Briefly, postural balance is achieved when the projection of the center of gravity is maintained within the base of support, which is the area between both feet. While standing, the body oscillates naturally in both anteroposterior and mediolateral directions. The body sway is controlled by the net center of pressure, which is the point of application of the resultant forces acting under the feet [1]. The amplitude of the net centre of pressure excursions of both anteropos-

terior and mediolateral directions is linked with the quality of postural control. More precisely, a larger net center of pressure amplitude and center of pressure velocity is associated with a poorer postural balance [2]. Furthermore, postural control requires the integration of several sensory informations arising from the visual, vestibular, and somatosensory systems [3].

Control of postural balance during standing is an essential task while performing surgery. The surgeon's postural sway must be well controlled in order to enhance movement accuracy. While performing an open surgery, the surgeon can use the operating table or the patient to stabilize himself and minimize the body sway, but when performing a laparoscopic task, such additional stabilization is less possible. A well-controlled postural balance is then essential in that type of minimally invasive surgical task.

The merging of a concurrent cognitive task to the upright standing is also believed to affect the postural control [4]. Allocating attention to a focal task during stance may reduce the attentional resources distributed to maintain pos-

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tural balance, thereby jeopardizing postural stability. On the other hand, attentional resources allocated to the focal task could be reduced because of the attentional demands for postural stability, thus jeopardizing the performance on the focal task [4]. When subjects are instructed to perform both tasks to the highest degree of their capacity, it is assumed that attentional priorities can be switched between tasks, requiring each task to contend against another for processing resources [4]. Furthermore, Pellecchia [5] showed that postural sway during standing on a compliant surface was greater when the difficulty of the concurrent cognitive task increased. The additional cognitive task associated to laparoscopic surgery seems to be very complex. Beyond having to worry about the current surgery and its possible complications, the surgeon must add a 3-dimensional motor task to the information coming from a 2-dimensional image.

Recently, Pellecchia [6] also demonstrated that the training of a cognitive or motor task while standing will improve the postural balance during that task. These findings are very interesting from a surgical point of view. This could indicate that an adequate training of the motor and cognitive task involved in laparoscopic surgery would enhance postural control of the surgeon while operating.

The purpose of the current study was therefore to compare postural control between novice and expert laparoscopic performers. We hypothesized that an expert surgeon would have a better postural control than a novice surgeon when performing a laparoscopic task.

Methods

Subjects

Two subjects groups with varying laparoscopic experience were recruited from McGill University for voluntary participation. All aspects of the study were approved by the Ste-Justine hospital research ethics committee, and all subjects gave informed consent. Seven novices (postgraduate years 3 and 4) with limited exposition to laparoscopy were compared with 7 experts (postgraduate year 5, fellow and surgeons) with ongoing laparoscopic experience. Indeed, the experts were exposed to advanced laparoscopic procedures such as radical nephrectomy and prostatectomy and had access to animal practice laboratories in order to improve their technical skills, while the novices were mainly exposed to dry lab practices. The novice group had a mean age of 33 ± 4 years, while the expert group had a mean age of 36 ± 7 years.

Equipment and methodology

The subjects were requested to perform a quiet standing task in addition to 4 laparoscopic tasks on the McGill Inanimate System for Training and Evaluation of Laparoscopic Skills (MISTELS) [7,8], which is now part of the Fundamentals of Laparoscopic Surgery [9], while standing on 2 force platforms. The quiet standing task required the subjects to stand still with 1 foot on each force platform. The subjects remained in that position for 30 seconds. The quiet standing task was performed in order to set a postural parameters standard for each of the subjects. The 4 MISTELS tasks performed were: pegboard transfer, pattern cutting, placement of ligating loop, and intracorporeal knot.

The technical difficulty increases from laparoscopic task 1 to 4. The times awarded for the different task were the ones attributed to each of the different MISTELS tasks. All of the subjects in this study were able to perform the given task within the time allocated. The sampling acquisition frequency of the force platforms was set at 60 Hz. The time-history of net center of pressure profile was calculated from the vertical, anteroposterior, and mediolateral ground reaction forces and the moment acting around each axes.

Data analysis

The root mean square amplitudes of the net center of pressure and the center of pressure velocity were calculated in both anteroposterior and mediolateral directions for all tasks. These measures have been shown to have excellent reliability in quiet standing [1,2,10], especially the center of pressure velocity [2,11]. Analysis of variance (ANOVA) with repeated measures was performed to compare groups and a Newman-Keuls post-hoc comparison test was used whenever necessary to compare the 5 different conditions. Significance level was set at $P < .05$.

Results

The data showed that technical requirements of the laparoscopic tasks impacted on postural sway in both anteroposterior and mediolateral directions, with the most difficult tasks showing the greatest root mean square amplitudes of the net center of pressure (Fig. 1). However, root mean square amplitude in mediolateral direction showed greater net center of pressure excursion for the loop task (task 4) compared to the other tasks. This can be explained by an important weight transfer associated with the task. Furthermore, root mean square amplitudes of the net center of pressure results indicate that the experts had a significantly ($P < .05$) better postural balance in both mediolateral (9.7 ± 2.7 mm vs 20.6 ± 2.7 mm) and anteroposterior ($7.6 \pm .9$ mm vs $11.4 \pm .9$ mm) directions and compared to novices for all tasks (Fig. 2). Finally, the center of pressure velocity results in both mediolateral (8.5 ± 1.2 mm/s vs 13.2 ± 1.2 mm/s) and anteroposterior ($7.0 \pm .7$ mm/s vs $9.4 \pm .7$ mm/s) directions were significantly ($P < .05$) better for the expert group compared to the novice group for all tasks.

Comments

This study established that the attentional demand related to a surgical task was sufficient to decrease the postural control of a surgeon. Furthermore, while performing identical tasks, the postural control was less affected for the expert surgeons when compared to the novices, the latter displaying increased net center of pressure excursion.

Surgeons performing laparoscopic surgery are frequently required to maintain a prolonged standing posture, which could affect psychomotor performance. This upright posture must be well controlled in order to enhance the efficiency of their motor tasks. A better postural control will reduce body sway and could facilitate the accomplishment of fine movements. Moreover, Larue et al [12] demonstrated that expert rifle shooters had reduced significantly their center of pressure excursion when compared to novice shooters in order

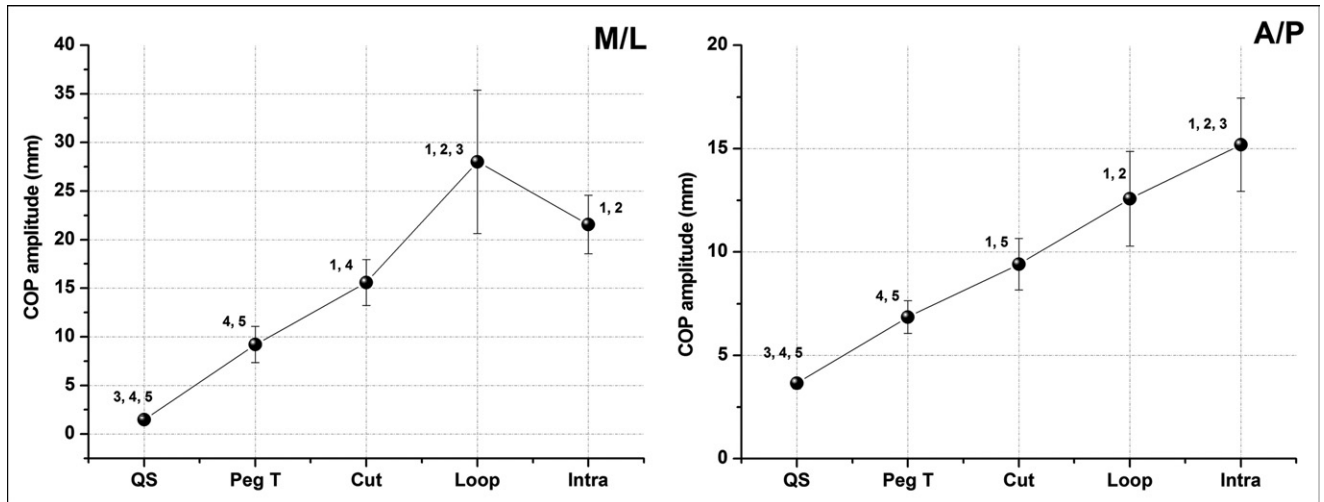


Fig. 1. Mean root mean square amplitude of the net center of pressure (COP in mm) in mediolateral (M/L) and anteroposterior (A/P) directions during quiet standing and the four MISTELS' laparoscopic tasks (QS = quiet standing; Peg T = pegboard transfer; Cut = pattern cutting; Loop = placement of ligating loop; Intra = intracorporeal knot.). Numbers 1 to 5 represent significant difference between tasks.

to stabilize their body when aiming at a target. The addition of a light touch as been proven to help stabilize the body sway while standing [13,14]. Jeka and Lackner [14] established that as little as 1N of light touch is sufficient to decrease the postural sway. Even if the effect of a light touch was not evaluated in this study, the light touch provided by the laparoscopic instruments on the trochars could have enhanced postural control of the surgeons when compared with the quiet standing task. Meanwhile, the results of this study show that the postural sway is greater for all of the surgical tasks, with the exception of the peg transfer task, when compared with the quiet standing task. However, the peg transfer task still showed a tendency of larger net center of pressure excursion than the quiet standing task. Furthermore, the results of this study are congruent with

those found by Gillette et al [15]. The postural control decreases with the difficulty of the surgical motor task. These findings demonstrate that the attentional demand associated with the tasks is important enough to challenge the postural control of the surgeon even with the presence of a light touch.

These results also concur with those obtained in a non-surgical-related dual-task environment. Recent studies have shown that the difficulty of a cognitive task had an effect on the postural control [4,5,16]. The attentional demand seems to increase with the level of difficulty of the surgical task. The surgeons who participated in this study increased their net center of pressure excursion, along with an augmentation of the difficulty of the motor task to realize. According to Weeks et al [4], attentional priorities seemed to switch continuously from the postural task to the motor task and probably affect both tasks. This circumstance appears to be the argument in the current study.

In addition to these results, this study also found that the novice surgeons displayed poorer postural control than expert surgeons while performing the surgical tasks on the MISTELS. These results show that an expertise level of a task acquisition will enhance postural control. According to Ericsson [17], practice is the only method to master a technique. Meanwhile, Pellecchia [6] demonstrated that the training of a cognitive or motor task while standing will improve the postural balance during that task. Our results are in agreement with these studies. The expert surgeons had previous experience and practice with laparoscopic tasks, while the novice surgeons had limited experience with laparoscopic training. The experience level of both groups in this study reveals that the training of a surgical task in a realistic environment will enhance the postural control of the surgeon. According to Pellecchia [6], a dual-task skill is best acquired through dual-task practice that provides the opportunity to coordinate and integrate component tasks.

The practice of laparoscopic surgical tasks in the operating room is not always possible for junior residents and

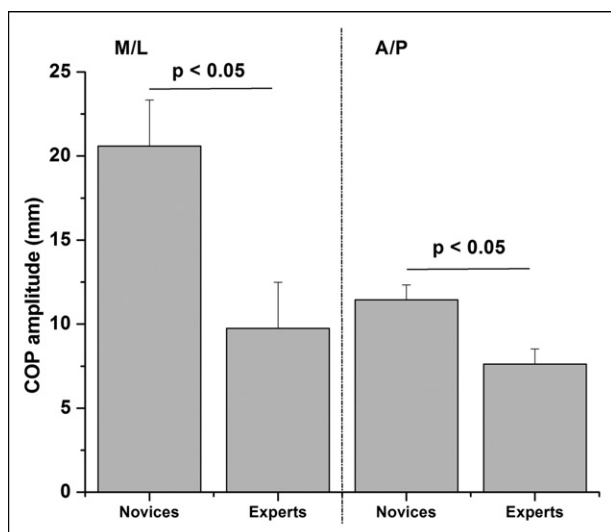


Fig. 2. Mean root mean square amplitude of the net center of pressure (COP in mm) in mediolateral (M/L) and anteroposterior (A/P) directions for novice and expert groups while performing all tasks.

more training opportunities should be provided [18,19]. However, several laparoscopic simulating devices have been developed in recent years. The main purpose of these simulating devices is to allow surgical residents and surgeons to practice and perfect their technical skills. Recently, Korndorffer et al [20] drew a very understanding picture of the evolution of skills laboratories in surgical programs. They reported that the desire to implant such laboratories was enhanced by many recent studies confirming the effectiveness of training using simulating devices in providing skills that improve performance during actual operations [21–26]. An interesting point also mentioned by Korndorffer et al [20] is that even if 88% of surgical program directors responding to a questionnaire considered that laparoscopic skills laboratories improve operating room performance, only 55% of these responders actually had a dedicated laparoscopic skills laboratory in their institution. Compared to what is known of open surgery, we are just beginning to understand the complexity of minimal invasive surgery. The technical requirements, as well as the postural attitude to maintain during those surgical tasks, have to be taken into consideration for optimal performance. Postural control seems to be a meaningful signal in tracking the technical difficulty and the learning stage of new minimally invasive surgical tasks. As recommended by Korndorffer et al [20], the results of the present study support the need to implant dedicated minimally invasive surgical skills laboratory in our institution in order to help residents acquire laparoscopic skills quicker while enhancing a more stable postural control.

In conclusion, the postural sway of both expert and novice surgeons increases progressively with the technical requirements. Meanwhile, postural control and laparoscopic skills seem to be closely associated. Experts show better postural control compared to novices in all tasks. A better postural control while standing may improve laparoscopic performances such as accuracy of movement.

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