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An ergonomic evaluation of surgeons' axial skeletal and upper extremity movements during laparoscopic and open surgery

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Abstract

Background: Many surgeons have complained of fatigue and musculoskeletal pain after laparoscopic surgery. We evaluated differences in surgeons' axial skeletal and upper extremity movements during laparoscopic and open operations.
Methods: Five surgeons were videotaped performing 16 operations (8 laparoscopic and 8 open) to record their neck, trunk, shoulder, elbow, and wrist movements during the first hour of surgery. We also compared postprocedural complaints of pain, stiffness, or numbness between the two groups.
Results: Compared with surgeons performing open surgery, surgeons performing laparoscopic surgery exhibited less lateral neck flexion; less trunk flexion; more internal rotation of the shoulders; more elbow flexion; more wrist supination and wrist ulnar and radial deviation. There was a trend of more shoulder stiffness after laparoscopic operations than after open operations.
Conclusions: Laparoscopic surgery involves a more static posture of the neck and trunk, but more frequent awkward movements of the upper extremities than open surgery. Ergonomic changes in the operating room environment and instrument design could ease the physical stress imposed on surgeons during laparoscopic operations. © 2002 Excerpta Medica, Inc. All rights reserved.

Keywords: Laparoscopy; Ergonomics; Posture

Laparoscopic surgical procedures are now being performed in all areas of general surgery. Laparoscopic advances such as development of higher resolution video optics and improved operating instruments have allowed surgeons to perform more advanced laparoscopic operations. However, there have been no concomitant changes in operating room design and video monitor set-up to ease musculoskeletal fatigue of surgeons performing laparoscopic surgery. Ergonomic studies therefore are needed to improve the operating room environment and reduce surgical fatigue.

Ergonomics is the science of fitting the work environment to the worker [1]. Laparoscopic surgery has changed the way surgeons interact with their operative field and hence changed their body postures and upper extremity movements. Laparoscopic surgeons tend to maintain a more upright position with fewer back movements and less weight shifting than surgeons performing open surgery [2]. Static back posture during prolonged laparoscopic operations may account for the increased postural fatigue of the back. In addition, the present design of laparoscopic instruments and the awkward positions of the arms, hands, and fingers required by laparoscopic operations can result in pressure point injury, nerve compression, and upper extremity fatigue [3–6]. The primary objective of this study was to record surgeons' axial skeletal and upper extremity movements during laparoscopic and open surgery using physical-therapy–derived guidelines for measuring posture and movements. The secondary end point was to compare surgeons' postprocedural reports of musculoskeletal pain and stiffness after laparoscopic and open operations.

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Materials and methods

We videotaped five surgeons performing eight laparoscopic and eight open operations. Surgeons' neck, back, and upper extremity movements exhibited during the laparoscopic operations were compared with those during the open operations. The video provided only a single frontal view of the surgeon's head to pelvis. Only the first hour of surgery was videotaped and analyzed due to limited time for review of the tapes. Immediately after the surgery, one of two physical therapy students (CP, RDV) from the Program of Physical Therapy at California State University, Sacramento, administered a questionnaire to each surgeon. The questionnaire asked for the presence of, the location of (neck, back, shoulder, hand/wrist on a drawing of a human body), and the severity of pain, stiffness, or numbness on a scale of mild, moderate, and severe.

The physical therapy students reviewed all videotapes and recorded the numbers of neck, trunk, shoulder, elbow, and wrist movements using predefined criteria developed by the Department of Physical Therapy. A single specific movement of the neck, back, shoulder, elbow, or wrist was defined as a deviation of the body posture from the neutral upright body position and included its return to the neutral body position. For example, a single movement of wrist supination was any rotational movement from the neutral position going in the direction of supination and back to the neutral position. Neck movements were categorized as flexion, extension, lateral flexion, and rotation. Trunk movements were categorized as flexion and rotation. Shoulder movements were categorized as flexion, abduction, and internal rotation. For elbow movements, the total number of flexion movements (including both $<90°$ and $>90°$) were counted. Wrist movements were recorded as pronation, supination, flexion, extension, ulnar deviation, and radial deviation.

Data were given as the mean number of specific movements $\pm$ standard deviation for each body part for both laparoscopic and open operations. Comparison of the number of movements during laparoscopic and open surgery was performed using unpaired *t* tests or Mann-Whitney *U* tests for nonparametric data. The percentage of surgeons in the two groups with postoperative pain and stiffness was compared using Fisher's exact tests. Statistical evaluations were performed using standardized software (Stat-View, SAS Institute Inc., Cary, North Carolina). A *P* value less than 0.05 was considered significant.

Results

Five surgeons (4 males) with a mean age of 43 years performed eight laparoscopic and eight open operations (Table 1). Only the first hour of all 16 operations was videotaped.

The mean number of movements of the neck during laparoscopic and open surgery is shown in Fig. 1. During laparoscopic procedures, surgeons made significantly fewer lateral neck flexions than during open procedures ($P < 0.01$). In open surgery, there was a non-statistically significant trend toward a higher number of neck rotations but fewer neck flexions.

Table 1
Ergonomic evaluation during eight laparoscopic and eight open operations

Type of operation	Procedure
Laparoscopic operations	Esophagectomy (n = 2)
	Roux-en-Y gastric bypass (n = 1)
	Sigmoid colectomy (n = 1)
	Staging for esophagus cancer (n = 2)
	Cholecystectomy (n = 2)
Open operations	Pancreatoduodenectomy (n = 2)
	Roux-en-Y gastric bypass (n = 3)
	Sigmoid colectomy (n = 1)
	Ventral hernia repair (n = 1)
	Inguinal hernia repair (n = 1)

The mean number of movements of the trunk during laparoscopic and open surgery is shown in Fig. 2. Surgeons made significantly fewer trunk flexions during laparoscopic than during open operations ($P = 0.05$). There was a trend toward fewer trunk rotational movements during laparoscopic operations than during open operations.

The mean number of dynamic movements of the shoulder during laparoscopic and open surgery is shown in Fig. 3. The number of internal rotation movements of the shoulder was significantly higher during laparoscopic than during open surgery ($P = 0.02$). There was, however, no significant difference in the number of shoulder flexions and extensions between surgeons performing laparoscopic and open procedures.

The mean number of movements of the elbow during laparoscopic and open surgery is shown in Fig. 4. Surgeons exhibited significantly more elbow flexions during laparoscopic than during open operations ($P < 0.01$).

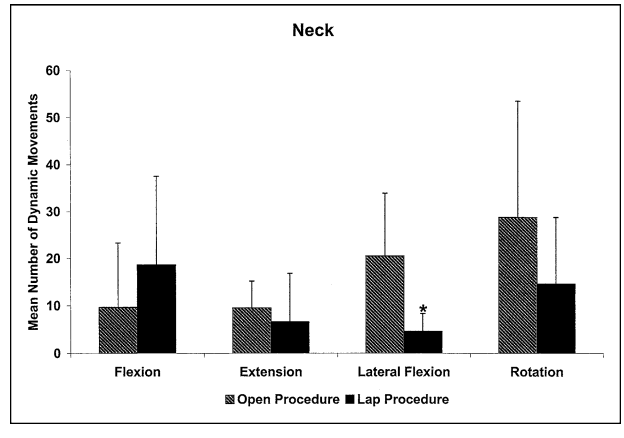

Fig. 1. Neck: the mean number of movements of the neck in the first hour of laparoscopic and open procedures. *$P < 0.05$ versus open surgery (Mann-Whitney *U* tests).

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