ALTERATIONS IN RESPIRATORY MECHANICS AFTER LAPAROSCOPIC AND OPEN SURGICAL PROCEDURES

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OBJECTIVE: To compare the effects of laparoscopic and open surgical procedures on postoperative strength and respiratory mechanics.

DESIGN: Prospective cohort study.

SETTING: Adult university hospital.

PARTICIPANTS: Fifty-one women aged 21 to 62 years scheduled to undergo elective cholecystectomy or hysterectomy (or related procedures), otherwise in good health.

INTERVENTION: Open or laparoscopic cholecystectomy or hysterectomy (or related procedures).

MAIN OUTCOME MEASURES: Maximum voluntary handgrip strength (HGS), forced vital capacity (VC), forced expiratory volume in 1 second (FEV1), and maximal inspiratory pressure (MIP) were each measured preoperatively and on the first postoperative morning. A visual analogue pain scale score was evaluated in relation to performance of the postoperative strength and respiratory measurements.

RESULTS: VC, FEV1 and MIP, but not HGS, were decreased after surgery. Postoperative VC, FEV1 and MIP were lower after open procedures than after laparoscopic procedures and after cholecystectomy than after hysterectomy (all p < 0.001). Pain scores were lower after laparoscopic than after open procedures (p < 0.005) and could account in part for differences in postoperative respiratory mechanics.

CONCLUSIONS: Cholecystectomy and hysterectomy do not result in generalized muscle weakness, unlike more major abdominal procedures. Postoperative alterations in respiratory mechanics are related to the site of the surgery, the use of an open versus a laparoscopic approach and postoperative pain.

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surgical procedures impose physiologic costs on patients that may have important functional and clinical consequences. Major abdominal procedures are accompanied by altered respiratory mechanics as well as a generalized reduction in muscle strength. The factors that may influence the physiologic effects of abdominal surgery include those related to the specific procedure (e.g., the magnitude of tissue dissection and the surgical site), to the patient (e.g., age and preoperative physiologic and medical status) and to perioperative care (e.g., postoperative pain, starvation and physical inactivity). The purpose of this study was to compare the effects of laparoscopic versus open surgical approaches on postoperative respiratory mechanics and muscle strength.

**METHODS**

Women in good general health, ranging in age from 21 to 62 years, were studied before and after four open and laparoscopic procedures as follows: open cholecystectomy (3 patients), laparoscopic cholecystectomy (29 patients), abdominal (open) hysterectomy (14 patients) and laparoscopic hysterectomy or other major gynecologic procedure (5 patients). Excluded were patients who had asthma, chronic lung disease, arthritis, or neuromuscular, metabolic or other disorders that might interfere with the measurements. Maximum voluntary handgrip strength (HGS), vital capacity (VC), maximal inspiratory pressure (MIP), and forced expiratory volume in 1 second (FEV₁) were measured at the predmission hospital visit, early on the morning of surgery (preoperative) and on the morning after surgery (postoperative). HGS was taken as the highest of three maximal voluntary contractions in the dominant hand 30 to 60 seconds apart, with the patient seated in a position of maximal comfort. HGS was measured with the use of a handgrip dynamometer (Jamar model 1 dynamometer; J.A. Preston, Toronto). MIP after tidal expiration, that is, at functional residual capacity, was measured with a pressure manometer (A.F. Hall, Burlington, Ont.). VC and FEV₁ were measured with a portable spirometer (Vitalograph Compact; Roxon Medi-Tech, Montreal). Pain was evaluated in relation to the performance of the postoperative strength measurements and spirometry on a visual analogue scale.

Patients were studied at least 1 hour after the administration of any narcotic. The protocol was reviewed and approved by the Research Ethics Committee of the Ottawa Civic Hospital, and written consent was obtained from all patients. All measurements in a given patient were conducted by one individual. Data were analysed by analysis of variance, Tukey’s honestly significant difference (HSD) test, the paired t-test, and multiple linear regression. The results are given as means (and standard deviations).

**RESULTS**

Patients in the four procedure groups were similar in terms of age, weight, body mass index, smoking status and preoperative VC, FEV₁, MIP and HGS (Tables I and II). Preoperative VC and FEV₁ increased as a function of height and decreased with age (r² = 0.38 and 0.48, respectively, all p < 0.002). HGS was weakly related to height (r² = 0.11, p < 0.05). Smoking status did not influence preoperative VC, FEV₁, MIP or HGS. The differences in the duration of open hysterectomy and laparoscopic hysterectomy (p = 0.06) and open cholecystectomy (which included two conversions from laparoscopic procedures) (Table II) approached statistical significance (p = 0.08).

**Table I**

<table>
<thead>
<tr>
<th>Variable</th>
<th>OC (n = 3)</th>
<th>LC (n = 29)</th>
<th>OH (n = 14)</th>
<th>LH (n = 5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean (and SD) age, yr</td>
<td>43 (15)</td>
<td>41 (12)</td>
<td>42 (8)</td>
<td>36 (5)</td>
</tr>
<tr>
<td>Mean (and SD) weight, kg</td>
<td>79 (12)</td>
<td>73 (19)</td>
<td>70 (15)</td>
<td>59 (10)</td>
</tr>
<tr>
<td>Mean (and SD) body mass index, kg/m²</td>
<td>30 (5)</td>
<td>28 (7)</td>
<td>26 (4)</td>
<td>22 (4)</td>
</tr>
<tr>
<td>Smoker, no. of patients</td>
<td>Yes</td>
<td>1</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>No</td>
<td>2</td>
<td>23</td>
<td>8</td>
<td>4</td>
</tr>
</tbody>
</table>

OC = open cholecystectomy, LC = laparoscopic cholecystectomy, OH = open hysterectomy, LH = laparoscopic hysterectomy.
VC, FEV₁, and MIP (all \( p < 0.001 \)) were decreased on the morning after operation, but HGS was not altered (Table II). Postoperative VC, FEV₁, and MIP (expressed as a proportion of preoperative values) were lower after open than after laparoscopic procedures, and after cholecystectomy than after hysterectomy (all \( p \leq 0.001 \)) (Fig. 1). VC, FEV₁, and MIP were lowest after open cholecystectomy (\( p < 0.005, 0.005, \) and 0.05 respectively versus other groups). Percent changes postoperatively were not related to preoperative values. Postoperative pain scores on a visual analogue scale were quite variable but were lower after laparoscopic than after open procedures (\( p < 0.05 \)) (Fig. 2). FEV₁ (\( p < 0.05 \)), MIP and VC (both \( p = 0.07 \)) after surgery were weakly related to the pain scale score on univariate analysis. Pain scale scores were more strongly related to postoperative VC (\( r^2 = 0.20, p < 0.05 \)), FEV₁ (\( r^2 = 0.28, p < 0.01 \)) and MIP (\( r^2 = 0.11, p = 0.07 \)) when the site of surgery was accounted for, but were no longer predictors when the use of a laparoscopic versus open approach was included in the analysis. Postoperative VC, FEV₁, and MIP were not influenced by age, smoking status, weight, height or duration of surgery.

**DISCUSSION**

Muscle strength and lung volumes are related to age and sex, in part reflecting differences in muscle mass.\(^1\) To minimize such variability and facilitate recruitment of generally healthy individuals to the various groups, we chose to study young and middle-aged women scheduled to undergo the procedures described. Even within this relatively homogeneous group,
age and body size (i.e., height) effects accounted for much of the variability in VC and FEV, although not that of HGS. Cholecystectomy and hysterectomy were chosen as being commonly performed laparoscopic and open surgical procedures that are of comparable magnitude in terms of tissue dissection and are conducted in similar, relatively homogeneous and healthy demographic groups. Patients scheduled to undergo open cholecystectomy and major laparoscopic gynecologic procedures were also studied in an attempt to account for differences between upper and lower abdominal procedures. The four groups were similar in terms of age, weight and other preoperative variables. The duration of the open hysterectomy tended to be shorter than those of open cholecystectomy and laparoscopic hysterectomy, but the duration of a surgical procedure was not a predictor of postoperative respiratory mechanics or other variables.

Muscle strength decreases after surgery in a dose-dependent fashion, that is, changes are most marked after major surgical procedures and are minimal or absent after minor procedures. MIP as well as VC and FEV, reflect respiratory muscle strength in part. However, the procedures we studied are limited in magnitude and did not result in changes in HGS, that is, in generalized muscle weakness. Thus, other factors must contribute to the observed changes in respiratory mechanics. Decreases in VC and FEV, after open abdominal surgery are well known to be influenced by the site of surgery, and our observations in patients who underwent open cholecystectomy and hysterectomy are similar to those of others. Alterations in diaphragm function contribute to the decreases in VC and FEV, that follow upper but not lower abdominal surgery, with neurologic reflex inhibition postulated as the physiologic basis. A recent study comparing laparoscopic cholecystectomy and herniorrhaphy, demonstrated that even with a laparoscopic approach, surgery in the upper abdomen results in significant postoperative impairment of diaphragm function. Our observations also are consistent with the concept that the site of surgery is an independent predictor of changes in respiratory mechanics, whether the procedure is laparoscopic or open.

Furthermore, we observed that postoperative decreases in VC, FEV, and MIP varied with the surgical approach, independent of the site of surgery. The more marked impairment of respiratory mechanics that follows open compared with laparoscopic cholecystectomy has been described consistently in other reports. Pain score was a significant predictor of postoperative respiratory function, an effect that was not present when the surgical approach was accounted for, suggesting that differences in the effects of laparoscopic and open procedures may be related in part to differences in pain accompanying the two approaches. Postoperative pain as reflected in pain scores and analgesic requirement, has typically been reported to be milder after laparoscopic than after open cholecystectomy. Relief of pain after upper abdominal procedures done with a variety of techniques, including epidural analgesia, has been associated with limited improvement in postoperative reductions in VC and functional residual capacity. However, diaphragm dysfunction itself does not appear to be altered even with effective analgesia.

CONCLUSIONS

Cholecystectomy and hysterectomy are limited surgical procedures that are not associated with generalized postoperative muscle weakness. The site of surgery and the surgical approach (laparoscopic versus open) influence postoperative respiratory mechanics, with changes being more marked after upper abdominal and open procedures. There is less pain after laparoscopic procedures, which may account in part for their less-marked effects on respiratory mechanics.

References


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**Books Received**

This list is an acknowledgement of books received. It does not preclude review at a later date.

Cette liste énumère les livres reçus. Elle n’en exclut pas la critique à une date ultérieure.


