Lung volumes 24 h after laparoscopic cholecystectomy – Justification for early discharge

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OBJECTIVE: To compare lung volumes after laparoscopic cholecystectomy (LC) and open cholecystectomy (OC).
DESIGN: Prospective study with matched historical controls.
SETTING: Referral teaching hospital.
SUBJECTS: Twenty-six healthy female subjects (age 20 to 40 years), 13 of whom had LC.
MAIN OUTCOME MEASURES: Vital capacity (VC, % predicted), functional residual capacity (FRC, % predicted) and analgesic frequency (mean ± SD) over the first 24 h.
RESULTS: Immediately after operation, FRC was similarly depressed to 80.4±1.8% in the OC group and 80.8±2.3% in the LC group. After 24 h FRC fell to 70.5±1.9% in the OC group and increased to 91.3±2.4% in the LC group. VC fell immediately postoperation to 41.4±4.8% in the OC group but to only 62.2±1.9% in the LC group. By 24 h, VC improved slightly to 52.5±2.7% in the OC group but returned to normal, 99.0±3.2%, in the LC group. Postoperative analgesic frequency over 24 h was less in the LC group, 3.3±0.8 versus 5.0±0.8.
CONCLUSION: Depression in lung volume is less with LC. A VC that returned to normal and a FRC level not usually associated with pulmonary complications support the practice of discharging LC patients by 24 h postoperation.

Key Words: *Cholecystectomy, Functional residual capacity, Laparoscopic cholecystectomy, Lung volumes, Vital capacity*

Volumes pulmonaires après une cholécystectomie par laparoscopie : justification pour donner rapidement congé aux patients

OBJECTIF : Comparer les volumes pulmonaires après une cholécystectomie par laparoscopie (CL) et après une cholécystectomie ouverte (CO).
MODÈLE : Étude prospective avec témoins historiques appariés.
CONTEXTE : Hôpital universitaire.
SUJETS : Vingt-six femmes âgées entre 20 et 40 ans dont 13 ont subi une cholécystectomie par laparoscopie.
PRINCIPALES MESURES DES RÉSULTATS : La capacité vitale (CV en pourcentage de la valeur théorique), la capacité résiduelle fonctionnelle (CRF en pourcentage de la valeur théorique) et la fréquence d'administration d'un analgésique (moyenne ± ET) pendant les premières 24 heures.
RÉSULTATS : Immédiatement après l'opération, on a observé un abaissement similaire de la CRF à 80,4±1,8 % dans le groupe CO et à 80,8±2,3 % dans le groupe CL. Après 24 h, la CRF s'était abaissée à 70,5±1,9 % dans le groupe CO et avait remonté à 91,3±2,4 % dans le groupe CL. La CV avait chuté immédiatement après l'opération jusqu'à 41,4±4,8 % dans le groupe CO mais seulement jusqu'à 62,2±1,9 % dans le groupe CL. Après 24 h, la CV s'était légèrement améliorée pour atteindre 52,5±2,7 % dans le groupe CO, mais était revenue à la normale soit à 99,0±3,2 % dans le groupe CL. La fréquence d'administration des analgésiques après l'opération, sur une période de 24 h, était moindre dans le groupe CL, soit 3,3±0,8 par rapport à 5,0±0,8 dans le groupe CO.
CONCLUSION : La chute des volumes pulmonaires est moins importante lors d'une CL. Une CV qui est redevenue normale et ne CRF qui n'est généralement pas associée à des complications pulmonaires appuient la pratique consistant à donner congé aux patients ayant subi une CL dans les 24 heures qui suivent l'opération.

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Changes in pulmonary function account for significant morbidity and mortality following surgery (1-3). Among different surgical procedures, abdominal surgery results in the greatest depression in pulmonary function (1). The frequency of these changes has been reported to be as high as 70% (4,5), and microatelectasis following abdominal surgery is regarded as a uniform occurrence. We have previously shown that following upper abdominal surgery there is a significant depression in vital capacity (VC) and functional residual capacity (FRC) as well as hypoxemia (1,3,6,7). The depression in VC is a strong predictor of postoperative pulmonary complications such as pneumonia and atelectasis (7).

Our previous data also suggested that incisional pain may contribute significantly to the depression in postoperative pulmonary function (3). We have further shown (6) that the right subcostal incision is associated with less pulmonary morbidity and depression of pulmonary function than the midline upper abdominal incision for elective cholecystectomy.

Laparoscopic cholecystectomy (LC) has been established as the standard for elective cholecystectomy, replacing the previously common open technique. Major advantages of the laparoscopic technique are a shorter hospital length of stay and earlier return to gainful employment, as well as decreased requirement for analgesia (8). Subjectively, there is no doubt that patients recover more quickly from the laparoscopic procedure, and one of the reasons for this smoother recovery may be this procedure's diminished effect on postoperative pulmonary function compared with the previously standard open procedure. Several studies (8-11) have reported on the changes in lung function following LC. Although the reported changes in lung volumes are qualitatively similar, Frazee et al (11) demonstrated a larger change in vital capacity post-LC. This difference may have been due to longer operative times in their study. Because many clinicians have questioned the safety of discharging patients from hospital within 24 h of LC, it is important to relate these changes in postoperative lung volumes to the potential for developing postoperative pulmonary complications within this time frame.

The aim of the present study was to measure postoperative lung volume changes in patients undergoing LC and to compare these changes with our previous data on lung volumes following open cholecystectomy (OC). From our previous data (7) pulmonary complications were very unlikely when VC was maintained above 60%. We reasoned that if the VC within 24 h of LC was maintained at above 60% of the preoperative value, then postoperative pulmonary complications would be unlikely, and this may justify discharge of these patients by 24 h – at least from the standpoint of maintenance of 'safe' lung volumes.

PATIENTS AND METHODS

Ethics committee approval was obtained for a randomized prospective controlled study involving young female patients with symptomatic gallstones requiring elective cholecystectomy. However, it soon became apparent that the study could not be randomized because most patients elected to have the laparoscopic procedure performed rather than the open procedure. Most reported series on this topic suffered this same drawback (8,9,12). It was decided to use a historical control from the authors' previous data (7), using identical exclusion criteria as well as preoperative, intraoperative and postoperative care with the exception of the technique used for the surgical procedure. The LC group was compared with a group of patients who had previously undergone elective cholecystectomy through a subcostal incision. It was also decided to restrict the patient population to females because in the previous study only two of the 15 control patients reported (7) were males. The 13 females reported in that study formed the OC group for comparison with the LC group of the present investigation, who were studied using identical methods. As in the authors' previous study, exclusion criteria were as follows: age younger than age 20 years or over 40 years; pre-existing pulmonary disease as shown by unusual cough, phlegm, breathlessness, wheezing and nasal catarrh; smoking (over 40 cigarettes/week); obesity (greater than 15% above the height/weight nomogram); and a history of physician-diagnosed asthma, heart disease or other disease requiring cardiac or respiratory drug therapy.

Thirteen patients scheduled for elective LC were sequentially entered into the study after satisfying the inclusion criteria. Similar to the previous study (7) all patients received 10 mg of morphine and 0.6 mg of atropine intramuscularly preoperatively, and the procedures were all conducted under general anaesthesia with endotracheal intubation using muscle relaxant and nitrous oxide-oxygen inhalation. Postoperative care was standardized in the same fashion as in the previous study. This included supervised deep breathing, coughing, turning and leg exercises by trained nursing personnel every 2 h for the first 24 h. At each turning period the patients were requested to take 10 deep breaths and cough three times.

Analgesia was confined to meperidine at a maximum dosage of 1.5 mg/kg on the request of the patient, the frequency of analgesic requests being recorded for later comparison. All the procedures were conducted by one general surgeon.

Measurements included FRC (by the closed circuit helium dilution technique) and VC in the supine position, as reported previously (1). The measurements were then repeated at 4 to 8 h and 24 h, postoperatively. All measurements were reported as a percentage of the preoperative values. Lung volume studies were conducted at least 1 h after analgesia if the patient had meperidine. The weights and ages of the patients were compared as well as the duration of anaesthesia.

Statistical analysis was conducted using the unpaired Student's *t* test with $P \leq 0.05$ considered statistically significant. All data are reported as mean ± SD.

RESULTS

Age, weight, duration of anaesthesia and analgesic requests: There was no statistically significant difference between the two groups in terms of age, weight and duration of anaesthesia (Table 1). There was a statistically significant in-

TABLE 1
Age, weight, duration of anesthesia and frequency of analgesic requests in the first 24 h after cholecystectomy for the open and laparoscopic groups

	Open cholecystectomy group (n=13)	Laparoscopic cholecystectomy group (n=13)	P
Age (years)	32.8±3.4	31.5±3.3	NS
Weight (kg)	61.3±1.6	62.2±1.9	NS
Duration of anaesthesia (mins)	109.0±4.7	110.4±5.5	NS
Frequency of analgesic requests	5.0±0.8	3.3±0.8	P<0.05

NS Not significant. Data are mean ± SD

crease in the frequency of analgesic requests in the OC group compared with the LC group (OC group = 5.0±0.8, LC group = 3.3±0.8, P<0.05) in the first 24 h after cholescystectomy.

Functional residual capacity results: There was no difference in the FRC immediately postoperation (4 to 8 h after the procedure) between the two groups (Figure 1): the OC group had a FRC of 80.4±1.8% compared with 80.8±2.3% for the LC group. However, there was a statistically significant difference in the FRC 24 h postoperatively. Whereas FRC fell from the immediate postoperative value to 70.5±1.9% in the OC group, the LC group improved their FRC to 91.3±2.4% of the preoperative value. This latter improvement in FRC in the LC group was statistically significant, and the value was also statistically significantly different from the corresponding lower value of the OC group.

VC results: Four to 8 h postoperatively VC in the control and LC groups with the OC group was 41.4±4.8% of the preoperative VC, compared with 62.2±1.9% in the LC group (Figure 2). By 24 h postoperation, the LC group had normalized VC to 99.0±3.2% of its preoperative value, whereas the control group still had a severely depressed VC of 52.5±2.7%, which was only slightly improved over the immediate postoperative value.

In a previous study (7) criteria for diagnosing a pulmonary complication were any three of the following: fever greater than 38°C for 48 h (consecutive), clinical signs of consolidation, abnormal chest x-ray on the fifth postoperative day, and 2+ or greater pus in two consecutive sputum samples. Using these criteria there were two respiratory complications – one with right lower lobe atelectasis and another with bibasilar atelectasis – in the OC group. The laparoscopic patients were instructed to keep a chart of their postoperative temperature after discharge, and on the fifth postoperative day their sputum was analyzed and a chest examination was conducted on an out-patient basis. Only if the sputum, chest examination or temperature was abnormal (greater than 38°C) was a chest x-ray ordered. No chest x-ray was considered necessary because there were no abnormalities in the other parameters in any of the laparoscopic patients. Although one of the criteria for diagnosing a postoperative pulmonary complication (ie, omission of a routine chest x-ray on the fifth postoperative day) was different between the two groups, no pulmonary complicatons were diagnosed in the laparoscopic group compared with two in the OC group.

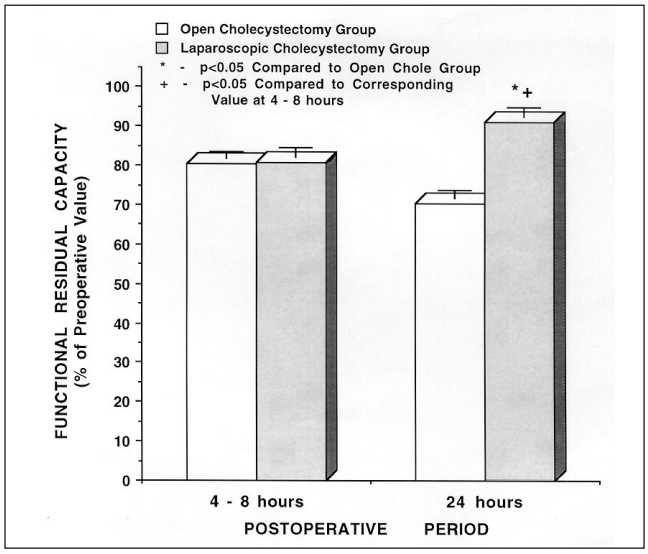

Figure 1) *Functional residual capacity (FRC) results (mean ± SD) obtained for the open cholecystectomy (OC) (n=13) and laparoscopic cholecystectomy (LC) (n=13) groups pre- and postoperatively. Although there was no difference in FRC immediately postoperation between the two groups, the LC group showed significant improvement in FRC by 24 h after surgery while the OC group showed a further decrease in FRC at 24 h after surgery*

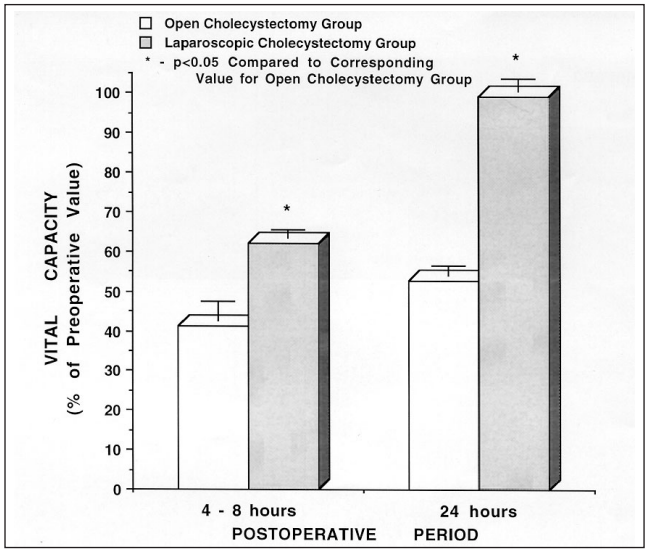

Figure 2) *Vital capacity (VC) (mean ± SD) results obtained for the open cholecystectomy (OC) (n=13) and laparoscopic cholecystectomy (LC) (n=13) groups, pre- and postoperatively. VC was more significantly depressed in the OC group. In the LC group, VC returned to normal within 24 h after surgery*

DISCUSSION

We found little compromise of lung volume following LC. Ideally, a randomized control group of OC patients would be required to compare postoperative pulmonary function between LC and OC patients. However, this was not

an ethically feasible option because patients uniformly chose the laparoscopic procedure rather than the open procedure. Our measurements in the LC group were, therefore, compared with those obtained for a matched group of OC patients. All conditions including age, sex, type and duration of anesthesia, exclusion criteria, and postoperative care were identical for both groups. The only difference between the two groups was the technique used for cholecystectomy. This, therefore, allowed a legitimate comparison by providing a control group, a factor that has been lacking in most other reported series.

Our data confirm our subjective assessment that patients undergoing LC do not suffer as severe a depression in lung volume as do patients undergoing standardized OC. Both the FRC and VC returned close to normal preoperative values by 24 h after LC. Also, as measured by the frequency of analgesic requests, it is apparent that the laparoscopic procedure is associated with significantly less pain. Because our control group was studied in the early 1980s, there have been significant changes in anaesthetic and postoperative analgesic management of cholecystectomy patients. Nitrous oxide-oxygen inhalation is not routinely used, and most patients are managed postoperatively by the patient control analgesia techniques. We chose the analgesic and anaesthetic techniques in our present study so that the study group would be identical with the historical control group except for the method used for the cholecystectomy procedure. Conceivably, use of more up-to-date anaesthetic and analgesic techniques would result in even better postoperative lung volumes after LC than those measured in our study.

We and others have previously suggested that the depression in pulmonary function after abdominal surgery is largely due to a restrictive defect as manifested by a significant immediate depression in VC (2,3,6,13). Although the depression in VC is partially improved with analgesic techniques, complete recovery of preoperative VC does not occur despite techniques such as epidural and intercostal blockade (4,14,15). This suggests that either incisional pain is not completely responsible for the depression in VC or that the analgesics do not completely eradicate the pain in these patients. Other workers have suggested that there may be a neurohumoral mechanism responsible for the depression in pulmonary function resulting from diaphragmatic dysfunction (14,16-18). These authors suggest that manipulation of the gallbladder may be responsible for initiating this response. The laparoscopic procedure obviously involves manipulation and traction of the gallbladder, which could conceivably result in the initiation of a similar neurohumoral effect as in the open technique resulting in diaphragmatic dysfunction and a depression in VC. Shulman et al (19) demonstrated alterations in ribcage-abdominal partitioning similar to those observed after OC. Another report (20) demonstrated that LC was associated with abnormal diaphragm function, but this was not as marked as in OC patients. We have previously shown that a VC of less than 60% of the preoperative value is a significant predictor of postoperative pulmonary complication including atelectasis, pneumonia and hypoxemia (3,6,7). In our present study the depression in VC after LC, although statistically significant, was just above the 60% mark, and the value of 62.2±1.9% of the preoperative VC immediately post-LC is probably a relatively safe value in terms of the prevention of postoperative pulmonary complications, such as hypoxemia, atelectasis and pneumonia. Failure to demonstrate any evidence of pulmonary complications in the LC group with maintenance of postoperative VC above 60% seems to corroborate of our previous data showing that maintenance of this level of postoperative VC is reasonable protection against the development of postoperative pulmonary complications following cholecystectomy. However, as indicated by others (21), the reported incidence of postoperative pulmonary complications can be significantly influenced by the criteria used for diagnosing pulmonary complications, and this factor must be considered when comparing results from different studies. By 24 h the VC was back to normal in the LC patients whereas the risk for postoperative pulmonary complication persisted in the OC group, which demonstrated a decrease in VC to 52.5% at 24 h postoperatively. The VC is regarded as a predictor of pulmonary complications because it is a measure of the patient's ability to breathe deeply and cough effectively. The practice of discharging LC patients within 24 h of surgery appears justified based on our data, which suggest that the recovery of pulmonary function is such that these patients are unlikely to develop pulmonary complications. The 'safe' level of VC (over 60% of preoperative VC) was achieved by as early as 8 h following LC.

Our exclusion criteria in this study did not allow assessment of well established risk factors for postoperative pulmonary complications such as obesity, cigarette smoking and previous cardiorespiratory disease. Other authors (22,23) have, however, demonstrated by multiple regression analysis that postoperative changes in lung function can be predicted by assessing these risk factors. The authors concluded that after considering all these risk factors the laparoscopic technique was associated with significantly smaller changes in postoperative lung function compared with the open technique.

The pattern of change in the FRC results was different from that seen in the VC, in that there was no difference in the FRC values between the two groups at 4 to 8 h postoperation. Our study does not allow an adequate explanation for this. Conceivably, pneumoperitoneum during LC (maintenance of an intra-abdominal pressure of 14 mmHg by carbon dioxide insufflation) may be responsible for diaphragmatic elevation during the procedure as well as some degree of depression of FRC during anaesthesia. Although diaphragmatic elevation secondary to pneumoperitoneum may account for the depression in FRC, Benhamou et al (24) have demonstrated that pneumoperitoneum per se does not result in diaphragmatic dysfunction, suggesting that although the diaphragm may be elevated with pneumoperitoneum, it still functions normally. Other authors (9,12) have demonstrated that diaphragmatic dysfunction does occur following LC, particularly during maximum effort such as during a VC ma-

noeuvre, suggesting that the surgical manipulation, separate from the pneumoperitoneum, may be responsible for the diaphragmatic dysfunction that contributes to depression of pulmonary function. Other authors (20) have suggested that lung compliance may be adversely affected by an increase in intra-abdominal pressure such as occurs during pneumoperitoneum for LC. All patients had the pneumoperitoneum decompressed on removal of the surgical ports for the procedure, although we did not measure the intra-abdominal pressure after termination of the procedure. There may be a delay in resolution of this fall in FRC after the pneumoperitoneum. However, whereas the OC group continued to demonstrate a fall in FRC 24 h postoperatively, reflecting possible atelectasis and hypoxemia, FRC normalized in the LC group. Although there may be a loss of lung volume secondary to pneumoperitoneum during the LC procedure, this is very short lived and does not appear to interfere significantly with postoperative pulmonary function as occurs in the standard OC procedure.

Our study, therefore, demonstrates that one of the reasons for the improved postoperative course of patients undergoing LC is the minimal depression in VC and FRC compared with the standard open procedure. This is further evidence of the superiority of this procedure over the open technique and justifies its use wherever possible, particularly in patients who may have pre-existing lung disease or who may be at greater risk of developing postoperative pulmonary complications.

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