Open *Versus* Laparoscopic Cholecystectomy

A Comparison of Postoperative Pulmonary Function

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Upper abdominal surgery is associated with characteristic changes in pulmonary function which increase the risk of lower lobe atelectasis. Sixteen patients undergoing open cholecystectomy and 20 patients undergoing laparoscopic cholecystectomy were prospectively evaluated by pulmonary function tests (forced vital capacity [FVC], forced expiratory volume [FEV-1], and forced expiratory flow [FEF] 25% to 75%) before operation and on the morning after surgery to determine if the laparoscopic technique lessens the pulmonary risk. Fraction of the baseline pulmonary function was calculated by dividing the postoperative pulmonary function by the preoperative pulmonary function and multiplying by 100%. Postoperative FVC measured 52% of preoperative function for open cholecystectomy and 73% for laparoscopic cholecystectomy (p = 0.002). Postoperative FEV-1 measured 53% of baseline function for open cholecystectomy and 72% for laparoscopic cholecystectomy (p = 0.006). Postoperative FEF 25% to 75% measured 53% for open cholecystectomy and 81% for laparoscopic cholecystectomy (p = 0.07). It is concluded that laparoscopic cholecystectomy offers improved pulmonary function compared to the open technique.

LAPAROSCOPIC CHOLECYSTECTOMY HAS been used in several medical centers in the United States in the past 2 years. The advantages of the laparoscopic technique include less patient discomfort, shorter hospitalization, and shorter interval to return to full activities after operation.[1] It has been postulated that due to the minimal incisional discomfort, postoperative pulmonary function following laparoscopic cholecystectomy would be improved as compared to open cholecystectomy. This study prospectively evaluated this hypothesis in patients undergoing elective cholecystectomy.

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Materials and Methods

A prospective evaluation of all patients undergoing either open or laparoscopic cholecystectomy during a 6-week period from May 1, 1990 through June 15, 1990 was performed. Patients undergoing concomitant common duct exploration were excluded from the study. This time period coincided with a stage early in our experience with laparoscopic cholecystectomy when one half of our surgeons were performing laparoscopic cholecystectomy and one half were not. New patients with symptomatic cholelithiasis were assigned randomly to individual staff surgeons, as is our customary practice, with no attempt to preselect patients into one operative procedure or the other. All patients were counseled before operation on routine postoperative pulmonary care, including use of the incentive spirometer.

Pulmonary function testing was performed before operation in all patients in the pulmonary lab using the Sensomedic 2800™ body plethysmography and flow volume loop. Forced vital capacity (FVC), forced expiratory volume at 1 second (FEV-1), and forced expiratory flow at 25% to 75% (FEF 25%–75%) were obtained. Bronchodilators were not administered during the testing. Absolute and percentage predicted values were measured.

The morning after surgery all patients underwent bedside pulmonary function using the Puritan Bennet PS 600™ processing spirometer, again measuring FEV-1, FVC, and FEF 25%–75%. Patient analgesia was individualized to meet each patient's requirements. This ranged from no analgesia to systemic narcotics.

A fraction of the baseline pulmonary function was calculated by dividing postoperative pulmonary function by the preoperative pulmonary function and multiplying by 100%. Statistical analysis was performed using the t test.

Results

During the 6-week study period, 16 patients underwent open and 20 patients underwent laparoscopic cholecystectomy. The indication for surgery in all patients was chronic symptomatic cholelithiasis. There were no cases of acute cholecystitis. There were 15 women and 1 man undergoing open cholecystectomy, with a mean age of 54 years (range, 21 to 86 years). Sixty-two per cent had a history of smoking more than one-half pack per day. There were 18 women and 2 man having laparoscopic cholecystectomy with a mean age of 47 years (range, 23 to 84 years). One half had a history of smoking more than one-half pack per day. No patient in either group was on chronic bronchodilator therapy (Table 1).

All surgeries were performed using general anesthesia. Open cholecystectomy was performed through a standard subcostal incision. Laparoscopic cholecystectomy was performed using a four trocar technique. Carbon dioxide was insufflated intraperitoneally during laparoscopic cholecystectomy with intra-abdominal pressures maintained at 20 mm mercury. Mean length of surgery was 70 minutes (range, 40 to 160 minutes) for open cholecystectomy and 87 minutes for laparoscopic cholecystectomy ($p = 0.18$). Mean duration of anesthesia was 114 minutes (range, 75 to 215 minutes) for open cholecystectomy and 129 minutes (range, 80 to 170 minutes) for laparoscopic cholecystectomy ($p = 0.20$).

Postoperative FVC measured 52% of preoperative function for open cholecystectomy and 74% for laparoscopic cholecystectomy ($p = 0.002$). Postoperative FEV-1 measured 53% for baseline function for open cholecystectomy and 72% for laparoscopic cholecystectomy ($p = 0.006$). Postoperative FEF 25%–75% measured 53% for preoperative functioning for open cholecystectomy and 81% for laparoscopic cholecystectomy ($p = 0.07$) (Table 2).

Discussion

The pulmonary effects of surgery and general anesthesia have been well documented. Impaired gas exchange occurs with the induction of general anesthesia and can be related to the effects of general anesthesia on distribution of ventilation, lung and chest wall mechanics, lung volumes, shunt fraction, and ventilation perfusion relationships.[2,3] Patient position, type of inhaled anesthetic, tidal volume, and airway pressure during general anesthesia can influence gas exchange and lung mechanics.[4,5]

Upper abdominal surgery can produce dysfunctional pulmonary mechanics independent of the effects of general anesthesia. Characteristically a restrictive pattern is seen with reductions in vital capacity and functional residual capacity (FRC).[6–8] After upper abdominal surgery, vital capacity may decrease by 50% or more, while functional residual capacity and tidal volume are reduced by 30%. Forced expiratory volume in one second will show similar postoperative decreases.[9] Latimer[8] demonstrated that this decrease in FEV-1 is secondary to a loss of lung volume rather than a major airway obstruction. The majority of patients undergoing extremity surgery using general anesthesia do not experience a similar decrease in FRC. Therefore this postoperative abnormality cannot be attributed to the effects of the anesthetic alone.[7,10]

The etiology of the pulmonary dysfunction after upper abdominal surgery is understood incompletely and multiple factors may contribute. Incisional pain produces a pattern of shallow inspiration to minimize discomfort. Functionally the chest and abdominal walls are interdependent during respiration. The increase in intra-abdominal pressure with expansion of the chest wall causes outward movement of the abdominal wall.[11] Incisional pain will restrict this outward movement. Relief of pain by epidural analgesia or intercostal block only partially restores vital capacity and FRC toward preoperative values. This indicates that upper abdominal incisions interfere with the ability to expand the thorax independent of pain factors alone.

Diaphragmatic dysfunction also plays a role in impaired ventilation. During normal respiration, 60% of the inspired tidal volume is contributed by a contraction of the diaphragm.[12] After upper abdominal surgery, diaphragmatic excursion is decreased[13] and paradoxical motion of the diaphragm can occur,[14] which leads to increased demand on intercostal muscle contribution to respiration. This change can cause a decrease in the functional residual capacity.

TABLE 1. *Patient Demographics*

Demographic	Open	Laparoscopic
Number	16	20
M:F	1:15	2:18
Mean age (years)	54 (21–86)	47 (23–84)
Smoking Hx	62%	50%

Hx, history.

TABLE 2. *Fraction of Baseline Pulmonary Function*

Function	Open (%)	Laparoscopic (%)	p Value
FVC	54	73	$p = 0.002$
FEV_1	52	72	$p = 0.006$
$FEF_{25\%-75\%}$	53	81	$p = 0.07$

The postoperative changes in pulmonary function improve gradually but are still demonstrable in most patients 5 to 7 days after surgery.[8,15] These changes become clinically significant when they contribute to pathologic conditions such as atelectasis, hypoxemia, and pneumonia.

The location and type of abdominal incision has been shown repeatedly to play a role in postoperative ventilatory impairment.[9,16–18] Laparoscopic cholecystectomy requires minimal muscle disruption and produces less postoperative pain. Because of these factors, it has been postulated that postoperative pulmonary dysfunction would be diminished. These benefits may be offset, however, by longer operating and anesthetic time required for laparoscopic cholecystectomy as well as pulmonary problems associated with the pneumoperitoneum performed during the procedure. The current study addressed this question in 26 patients. The three pulmonary functions tested (FVC, FEV-1, and FEF 25%–75%) all demonstrated approximately 20% to 25% better function in the patients undergoing laparoscopic cholecystectomy compared to the patients undergoing open cholecystectomy. These differences were present despite longer anesthetic and operative times for the laparoscopic cholecystectomy group. The physiologic alterations associated with upper abdominal surgery are reduced significantly with the laparoscopic technique. The advantages demonstrated by pulmonary function testing should translate clinically into better gas exchange, improved functional residual capacity, and better lung volume. This improvement in pulmonary function may translate into a lower incidence of respiratory complications.

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Discussions

Dr. Henry Laws (Birmingham, Alabama): In Dr. DeBakey's elegant presidential address he emphasized the two major advances that have made surgery as we know it possible: anesthesia in the United States and antisepsis in Europe. I would like to go a little further with this.

The major advances in the latter half of the 20th century, in my judgment, include the development of the pump oxygenator, intravenous nutrition, fiberoptics, video control operations, and transplantation.

I was privileged to hear Drs. Rhoads, Dudrich, Vars, and Wilmore present their paper on intravenous nutrition at this meeting at this hotel in 1968. Video-controlled surgery is changing and will dramatically alter surgery as we know it, not just cholecystectomy.

I would like to comment primarily on paper number 32, and I would like to thank Drs. Roberts and Frazee for sending me a copy of their manuscript.

The authors report a simple but crisp study of a major parameter of postoperative change, that of pulmonary function. Dr. Roberts and colleagues found, as have others, that significant features of pulmonary function are decreased by approximately 50% in the immediate postoperative period by subcostal incision. They have demonstrated that laparoscopic cholecystectomy does impair function significantly less than does open cholecystectomy.

As a matter of fact, the decrease was only about 25% with laparoscopic cholecystectomy, as opposed to 50% with open cholecystectomy.

I have several questions for these authors. Your time of operation with laparoscopic cholecystectomy was a little longer. Now that you have more experience with that operation, does it equal that of open cholecystectomy?

You note in your manuscript that you use a four-portal technique. We use a five-portal McKernan technique, one for the light source, two for each hand of the surgeon, and one for each hand of the assistant. Do you use two ports for the surgeon or two ports for the assistant?

Have you now studied more patients with pre-existing pulmonary dysfunction as opposed to those with relatively normal pulmonary function and determined the amount of additional impairment by open as opposed to laparoscopic cholecystectomy?

Considering patients with COPD, do you intend to change the criteria you might use to proffer operation, that is, by the laparoscope as opposed to the open operation that you were doing last year?

It pleased me to note that you used the open technique for your initial entry. Because 85% of our patients have had a previous abdominal operation, indeed, several have had at least two previous laparoscopic procedures, we think that should be done in every instance. Is that what you do?