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Title: DOES LAPAROSCOPIC CHOLECYSTECTOMY PREVENT POSTOPERATIVE PULMONARY FUNCTION DETERIORATION?

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Upper abdominal surgery such as cholecystectomy is associated with significant reduction in postoperative lung volumes (1) which lead to atelectasis, pneumonia, and hypoxemia. Laparoscopic cholecystectomy performed through an abdominal stab wound obviates the need for an incision. We undertook a prospective study to compare postoperative pulmonary function tests between patients undergoing laparotomy and laparoscopy for cholecystectomy.

After institutional review board approval, patient consents were obtained. Pulmonary effects of cholecystectomy were assessed following laparotomy in 8 patients and laparoscopy in 11 patients. Vital capacity (VC), forced vital capacity (FVC), forced expiratory flow ($FEF_{25-75\%}$) and maximum voluntary ventilation (MVV) were measured in the sitting position both preoperatively and one day postoperatively using bedside spirometry. During the postoperative interview pain was assessed employing a standard visual analogue scale. Patients with obesity, age greater than 60 years, history of smoking or history of lung disease were excluded. All surgery was performed under general anesthesia utilizing varying amounts of thiamylal, midazolam, droperidol, inhalational agents, and muscle relaxants. Narcotics were restricted to fentanyl and doses were limited to less than 5 mcg/kg. Using each patient as his own control, data was collected and calculated as a percent of the predicted value based on age and height, then analyzed using student's t-test. A $p<0.05$ was considered statistically significant.

VC, FVC, MVV fell significantly more following laparotomy than laparoscopy. VC, FVC, MVV decreased 37±15%, 37±11%, 39±10%, respectively following laparotomy compared to 7+9%, 15±15%, 20±9% respectively following laparoscopy. Visual analogue pain scale evaluations in both groups were similar. Consequently, we are able to eliminate the influence of a postoperative pain differential on our results.

The data confirm a significant depression of lung volumes following laparotomy and substantially less depression of lung volumes after laparoscopy. Post-laparotomy diaphragmatic dysfunction may account for the observed differences (2). Because reduced postoperative lung volumes are associated with atelectasis, pneumonia and hypoxemia, it is reasonable to assume that post-laparoscopic cholecystectomy patients are at considerably less risk for these complications than post-laparotomy patients.

1. J Clin Invest 12:651, 1932
2. Anesthesiology 68:379, 1988

Table

Preoperative vs Postoperative Pulmonary Function Tests as Per Cent of Predicted Value*

Test	Laparotomy Group Preoperatively	Laparotomy Group Postoperatively	Laparotomy Group Change	Laparoscopy Group Preoperatively	Laparoscopy Group Postoperatively	Laparoscopy Group Change
Vital Capacity	.75	.36	-.37±.15	.84	.77	-.07±.09
Forced Vital Capacity	.74	.36	-.37±.11	.80	.65	-.15±.15
Forced Expiratory $Flow_{25-75}$	.85	.38	-.47±.31	.85	.59	-.26±.16
Maximum Voluntary Ventilation	.67	.29	-.39±.10	.69	.48	-.20±.09

*The P value for vital capacity is 0.0000; for forced vital capacity is 0.0040; for forced expiratory $flow_{25-75}$ is 0.0665; and for maximum voluntary ventilation is 0.0008.

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TITLE: EFFECT OF CHANGES IN PCO_2 ON THE MATCHING OF VENTILATION AND PERFUSION IN NORMAL LUNGS.

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Pulmonary shunting is often increased in hyperventilated anesthetized patients(1). In contrast, mild hypercapnia may enhance gas exchange(2). We studied the effects of changes in PCO_2 and the influence of method of hyperventilation (increased respiratory rate [RR] versus tidal volume [TV]) on the matching of ventilation ($\dot{V}A$) and perfusion ($\dot{Q}$) in dogs, using the multiple inert gas elimination technique. We hypothesized that hypocapnia would impair $\dot{V}A/\dot{Q}$ matching.

Methods: 8 pentobarbital-anesthetized, closed-chested dogs were hyperventilated with $FIO_2 = 0.21$ by increased TV (TV = 30 ml/kg at 18 breaths/min) or increased RR (TV = 18 ml/kg at 35 breaths/min). Inspired CO_2 was added to change $PaCO_2$ to 20, 35, and 52 mmHg. The order of type of ventilation and $PaCO_2$ level was randomized. A dilute solution of six inert gases (SF_6, ethane, cyclopropane, halothane, diethyl ether, and acetone) was infused to assess gas exchange. Arterial and mixed venous blood gases and inert gases, mixed expired inert gases, and hemodynamics were measured. $\dot{V}A/\dot{Q}$ mismatch (heterogeneity) was assessed by shunt ($\dot{Q}S/\dot{Q}T$), dead space (VD/VT), log standard deviation of perfusion (log $SD\dot{Q}$) and ventilation (log $SD\dot{V}$) distributions and arterial-alveolar difference ([a-A]D) area. Data were analyzed by a two-factor within subjects analysis of variance, paired comparison *t* test, and Duncan test.

Results: When hypocapnia was achieved by high RR ventilation, $\dot{V}A/\dot{Q}$ mismatch was increased, indicated by increases in (a-A)D area with low $PaCO_2$ compared to normal $PaCO_2$ (see table). In contrast, hypocapnia did not affect $\dot{V}A/\dot{Q}$ matching with increased TV ventilation. Hypercapnia did not affect $\dot{V}A/\dot{Q}$ heterogeneity with either type of ventilation. Increased TV ventilation reduced VD/VT and log $SD\dot{V}$, but otherwise did not affect gas exchange during normocapnia. Ppa, $\dot{Q}T$, and $\dot{Q}S/\dot{Q}T$ were unchanged.

Table. Gas exchange measurements.

	$\dot{Q}S/\dot{Q}T$(%)	VD/VT(%)	log $SD\dot{Q}$	log $SD\dot{V}$	(a-A)D area
Increased RR					
Low $PaCO_2$	0.1 ± 0.0	36 ± 4	0.81 ± .06	1.4 ± .1	0.47 ± .04*
Normal $PaCO_2$	0.1 ± 0.0	37 ± 3	0.75 ± .05	1.2 ± .1	0.37 ± .05
High $PaCO_2$	0.1 ± 0.1	35 ± 3	0.75 ± .05	1.2 ± .1	0.39 ± .06
Increased TV					
Low $PaCO_2$	0.1 ± 0.0	31 ± 3+	0.75 ± .05	0.9 ± .1+	0.29 ± .04+
Normal $PaCO_2$	0.2 ± 0.1	28 ± 3+	0.75 ± .05	1.0 ± .1+	0.32 ± .04
High $PaCO_2$	0.3 ± 0.2	27 ± 3+	0.75 ± .05	1.0 ± .1	0.32 ± .04

Means ± SE are presented. *P < 0.05 versus normal $PaCO_2$; +P < 0.05 versus increased RR at same $PaCO_2$

Conclusion: We conclude that hypocapnia increases $\dot{V}A/\dot{Q}$ mismatch in dogs with normal lungs, when hyperventilation is achieved with a rapid RR, but not a large TV. Because increased lung volume may reduce the effect of CO_2 on collateral ventilation(3), the lack of effect of hypocapnia on $\dot{V}A/\dot{Q}$ matching with large TV ventilation suggests the importance of hypocapnic bronconstriction in mediating hypocapnia-induced $\dot{V}A/\dot{Q}$ mismatch in dogs.

References: 1) Michenfelder JD: *J Appl Physiol* 21:1471, 1966. 2) Swenson ER: *FASEB J* 2:A924, 1988. 3) Ingram RH: *J Appl Physiol* 40:720, 1976. Supported by B.B. Sankey Anesthesia Advancement Award, NHLBI Clinical Investigator Award (#HL02507), and HL12174.