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One-lung Anesthesia in Morbidly Obese Patients

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Gastric stapling has become an accepted treatment for refractory morbid obesity.[1,2] Although the procedure usually is performed through an abdominal incision, a transthoracic transdiaphragmatic approach recently has been described which provides an improved operative exposure.[3] However, details of the anesthetic management, intraoperative ventilation, and patient postoperative pulmonary courses were not mentioned in that study.[3] How well morbidly obese patients tolerate thoracotomy has not been reported. We therefore studied the intra- and postoperative courses of morbidly obese patients undergoing transthoracic gastric stapling surgery and compared them to patients undergoing the gastric stapling procedure by the conventional abdominal approach.

METHODS

This study was approved by the Human Subjects Committee of Stanford University. Informed consent was obtained from 16 morbidly obese patients undergoing gastric stapling surgery who were randomly assigned for either an abdominal (Group 1, eight patients) or thoracic (Group 2, eight patients) surgical approach. Spirometric pulmonary function tests (PFT) and an arterial blood-gas sample (ABG) while breathing room air (RA) were obtained from each patient preoperatively. All patients had fasted for at least ten hours prior to surgery and were brought to the operating room unpremedicated. An intravenous line and a radial artery cannula were inserted. Anesthesia was induced with thiopental (350–750 mg, iv), and succinylcholine (100–140 mg, iv) was used to facilitate endotracheal intubation. Patients in Group 1 had their trachea intubated with an endotracheal tube while patients in Group 2 had a polyvinyl chloride double-lumen endobronchial tube inserted. After confirmation of the correct tube position by auscultation, patients in Group 2 were placed in the right lateral decubitus position. All patients were paralyzed with pancuronium bromide and ventilated by a volume controlled ventilator at a tidal volume of 15ml/kg ideal weight and a rate of 10/min. Ideal weight was determined from the standard Metroplitan Life Insurance Company weight/height table.[4] The ventilatory rate was adjusted to keep the Pa_{CO_2} between 35–40 mmHg as determined by frequent ABG samples. Anesthesia was initially maintained in both groups with nitrous oxide and enflurane, and small amounts of iv fentanyl (0–0.2 mg). At the time of elective collapse of the lung in Group 2 patients, and when intra-abdominal diaphragmatic retractors were placed in Group 1 patients, N_2O was discontinued. The ventilator tidal volume was continued unchanged (15 ml/kg ideal weight) in both groups.[5] With an FI_{O_2} of 1.0, ABG were obtained at the time of gastric stapling in both groups. PEEP was not required in any patient and all patients had their trachea extubated within 2 h after the completion of the operation. On the first and second post-operative days, ABG (RA) and bedside PFTs were obtained from each patient.

At the end of the study, data were analyzed using Student's *t* test and chi-square analyses.

RESULTS

Patients in Group 1 and 2 were compared to each other with regard to age, weight, height, preoperative ABGs and PFTs, and there were no statistically significant differences between the two groups (table 1). Surgery lasted 90–120 minutes in both groups. In Group 2, the left lung was completely collapsed during operation for 45–60 minutes. Higher peak inspiratory pressures were required to deliver the same tidal volume to the single ventilated lung in Group 2 patients compared to Group 1. Intraoperatively, at the time of gastric stapling, with an FI_{O_2} of 1.0, the Pa_{O_2} was significantly higher in Group 1 as compared to Group 2 ($P < 0.01$) (table 2). However, no patient became hypoxemic ($Pa_{O_2} < 70$ mmHg) and there were no intraoperative complications in either group. The alveolar arterial oxygen tension differences ($A\text{-}aD_{O_2}$) were calculated in both groups with mean values of 341 mmHg in Group 1 and 540 mmHg in Group 2. The postoperative hospital course as assessed by ABGs and bedside PFTs taken on postoperative days

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TABLE 1. Preoperative Comparison of Group 1 (Abdominal) *vs.* Group 2 (Thoracic) Gastric Stapling Patients

	Group 1 (n = 8)	Group 2 (n = 8)
Age (years)	40.1 ± 0.7	38.9 ± 0.8
Height (cm)	165.7 ± 0.7	173.0 ± 1.5
Weight (kg)	128.3 ± 2.9	134.6 ± 3.3
Preoperative		
Pa_{O_2} (mmHg)	77.6 ± 1.6	79.0 ± 1.5
Vital capacity (liters)	3.5	4.0

Values are means ± SE.

1 and 2 were similar in both groups (tables 2 and 3). Although Group 2 patients tended to have greater decreases in vital capacity from their preoperative levels on postoperative days 1 and 2 than Group 1 patients, these differences were not significantly different (table 3).

DISCUSSION

Although the transthoracic surgical approach to gastric stapling has been recommended[3] there have been no reports of how morbidly obese patients tolerate thoractotomy with selective collapse of a lung for "one-lung" anesthesia. All our patients had their respiratory status studied preoperatively by ABG and spirometry. Although their mean Pa_{O_2} was less than expected for similar aged nonobese patients, no patient in either group had hypercarbia. PFTs demonstrated mild to moderate restrictive disease in all patients, probably due to decreased chest wall compliance and not to intrinsic lung disease.

In the nonobese anesthetized surgical patient there is a decrease in functional residual capacity (FRC), and airway closure may occur during tidal breathing.[6] These changes are exaggerated in the morbidly obese patient with marked reductions in FRC, expiratory reserve volume, and total lung compliance.[7] When anesthetized paralyzed patients are placed in the lateral decubitus position and mechanically ventilated, preferential ventilation of the upper lung occurs.[8] This, coupled with increased perfusion to the lower lung may result in marked ventilation/perfusion mismatch. During one-lung anesthesia, a large alveolar-to-arterial oxygen tension difference is common, often leading to systemic hypoxemia. The most important reason for this is the continued perfusion of the nondependent, nonventilated lung by as much as 25 per cent of the cardiac output. We believe these patients should be ventilated with 100 per cent oxygen because of the variability and unpredictability of the degree of $A\text{-}aD_{O_2}$ during "one-lung" anesthesia (table 2).

In our study, the Pa_{O_2} values in the thoracic group were lower than those of the abdominal group intraoperatively, presumably due to the shunting of blood through the unventilated upper lung. However, no patient became hypoxemic while breathing 100 per cent O_2 and there were no complications in either group. The absence of severe hypoxemia in Group 2 patients may be due in part to the salutary effect of the lateral decubitus position in reducing recumbent abdominal pressure by allowing the panniculus to displace itself on the operating table. The reduced abdominal pressure may allow for greater diaphragmatic excursion.[9] If the high intra-abdominal pressure in obese patients is relieved by passively retracting the abdominal wall, FRC probably increases to that of nonobese patients.[10] This is illustrated in a patient we recently reported in whom marked improvement in Pa_{O_2} occurred after a massive abdominal panniculus was mechanically lifted.[11]

The postoperative courses in both groups were identical. There were no anesthetic or surgical complications in any patient. There was a marked drop in vital capacity

TABLE 2. Arterial Oxygen Tensions (Mean ± SE) in Group 1 (Abdominal) and Group 2 (Thoracic) Gastric Stapling Patients

	Pa_{O_2} (mmHg)	
	Group 1 (n = 8)	Group 2 (n = 8)
Preoperative (room air)	77.6 ± 1.6	79.0 ± 1.5
Range	(57–98)	(66–96)
Intraoperative (100 per cent O_2)*	318.3 ± 11.5	130.3 ± 7.5
Range	(195–443)	(72–230)
Postoperative (room air)		
Day 1	64.9 ± 1.2	60.9 ± 1.0
Range	(56–76)	(48–75)
Day 2	62.3 ± 1.0	58.6 ± 1.0
Range	(51–67)	(47–72)

* $P < 0.01$.

TABLE 3. Comparison of Pulmonary Function Between Group 1 (Abdominal) and Group 2 (Thoracic) Gastric Stapling Patients

	Group 1	Group 2
Preoperative		
VC	3.5	4.0
FEV_1	2.7	3.2
Postoperative day 1		
VC	1.7	1.5
FEV_1	1.1	1.1
Postoperative day 2		
VC	2.2	2.1
FEV_1	1.2	1.2

VC = vital capacity (liters); FEV_1 = forced expiratory volume (liters), 1 second.
Values are means.

on postoperative days 1 and 2 for patients in both groups. This has been demonstrated previously in morbidly obese patients following abdominal incisions.[12,13] In these studies the fall in Pa_{O_2} was greatest on the second postoperative day and began to return towards the preoperative "normal" value on postoperative day 3.[12, 13] After thoracic surgery in morbidly obese patients, a similar depression in respiratory status occurred on the first and second postoperative days (tables 2 and 3). The respiratory variables we studied (PFT and ABGs) were similar for patients in both our groups. However since we did not follow our patients' pulmonary status after postoperative day 2, we do not know if there was a difference between groups thereafter. The average postoperative hospital stay was identical for both groups (8 days). We conclude that morbidly obese patients can tolerate one-lung anesthesia for transthoracic gastric stapling surgery with comparable safety to the abdominal approach.

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Precipitation of Local Anesthetic Drugs in Cerebrospinal Fluid

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Bupivacaine, etidocaine, mepivacaine, and tetracaine solutions have been stated to precipitate in CSF (cerebrospinal fluid).[1] This conclusion was based on an *in vitro* aerobic study, in which human CSF was frozen, reconstituted at a later date, mixed with solutions of the local anesthetic drugs, and titrated to the *p*H of CSF. The authors cautioned that injection of these drugs into the subarachnoid space might cause spinal cord damage.[1] Also, when CSF is added to solutions of tetracaine or its lyophilized (Niphanoid, crystalline) form, turbidity may occur, depending on the *p*H of the CSF, the temperature, the amount of the drugs, the diluent employed, and the duration of its exposure to air.[2] Likewise, when solutions of dibucaine are mixed with CSF in a syringe without the addition of glucose, a precipitate results.[3] Finally, Scott *et al.*[4] believe that precipitation of an etidocaine solution when combined with CSF is not unique to that drug, and that it occurs with solutions of bupivacaine and tetracaine.

In 40 years of performing spinal anesthesia with solutions of all of these drugs except etidocaine, this author has yet to observe precipitation when aspirating CSF into the syringe containing these local anesthetics. Therefore, this investigation was undertaken to determine which formulations of the local anesthetic drugs precipitate when combined with CSF under anaerobic conditions such as exist in the subarachnoid space.

Method

The withdrawal of CSF when performing spinal anesthesia for a surgical procedure received approval of the Human Rights Committee of The Virgina Mason Medical Center, provided that the patient gave verbal consent. A total of 93 patients were studied.

The single-dose ampules or vials of the commonly used

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