ORIGINAL ARTICLE

Hemodynamic Changes During Laparoscopic Gastric Bypass Procedures

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Hypothesis: Significant detrimental intra-operative hemodynamic and respiratory changes occur in the morbidly obese during laparoscopic gastric bypass.

Design: Case series.

Setting: Tertiary care university hospital.

Patients: Thirteen patients, 10 women and 3 men, undergoing uncomplicated laparoscopic gastric bypass for morbid obesity.

Interventions: Using a pulmonary artery catheter and an arterial line, we intraoperatively monitored hemodynamic and respiratory parameters. Parameter values were recorded at set points of the procedure, and the changes were statistically analyzed.

Results: Significant hemodynamic and respiratory changes, mostly unfavorable, occur in the morbidly obese when creating the pneumoperitoneum in preparation for laparoscopic gastric bypass. The hemodynamic changes are attenuated when the patient is placed in the reverse Trendelenburg position and almost completely corrected when the abdomen is deflated at the completion of the procedure. The respiratory changes are more persistent.

Conclusions: Laparoscopic gastric bypass surgery for morbid obesity leads to a number of predominantly detrimental, if temporary, respiratory and hemodynamic changes, which are most pronounced at the time of creation of the pneumoperitoneum. In the presence of significant cardiopulmonary comorbidities, the use of invasive intra-operative hemodynamic monitoring of the morbidly obese undergoing laparoscopic gastric bypass appears therefore justified.

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WITH THE INCIDENCE of morbid obesity increasing rapidly in the United States, there is growing interest in surgical treatment of the disease. The Roux-en-Y gastric bypass is now considered the surgical treatment of choice because of its improved long-term weight loss compared with other surgical options.[1] Since it was first described by Wittgrove et al,[2] the laparoscopic approach to Roux-en-Y gastric bypass has become increasingly popular and is being performed at many institutions across the country.

Several hemodynamic studies were performed when laparoscopic cholecystectomy first became popular.[3-8] These studies show that generally laparoscopy can be performed safely, but that high-risk patients may benefit from invasive hemodynamic monitoring.[6,9-11] Morbidly obese patients have many comorbid conditions related to their obesity, which include cardiovascular and pulmonary diseases. To date, there are limited studies reporting hemodynamic changes encountered during laparoscopic gastric bypass surgery on morbidly obese patients. We report the hemodynamic changes observed in the course of the procedure in a series of 13 such patients.

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METHODS

Thirteen patients, 10 women and 3 men, underwent laparoscopic gastric bypass without intra-operative complications between September 1999 and April 2000. The average age was 43 years, and ages ranged from 28 to 57 years. The average body mass index (calculated as weight in kilograms divided by the square of height in meters) was 56 kg/m^2; body mass index ranged from 45 to 72 kg/m^2. Significant comorbidities were identified before surgery in several patients. Six of the patients had asthma, 4 had hypertension, 3 had diabetes mellitus,

Table 1. Demographic and Clinical Data of the Patients

No.	13
Sex, M:F	3:10
Age, y, mean ± SD	43.1 ± 8.5
Body mass index, kg/m^2, mean ± SD	55.9 ± 7.8
Operative time, min, mean ± SD	191 ± 47

2 had a previous cerebral vascular accident, and 1 had coronary artery disease. The relevant demographics and clinical findings of the patients are presented in **Table 1**.

A cardiac workup, consisting of a cardiological evaluation and an echocardiogram, was obtained for all the patients as part of their standard preoperative evaluation. In addition, some patients underwent stress testing depending on risk factors and the results of the initial clinical cardiac evaluation. All patients also received pulmonary evaluation preoperatively, which included baseline arterial blood gas values and pulmonary function testing. High-risk patients underwent sleep apnea studies.

On the day of surgery, a pulmonary artery catheter (Arrow Int, Reading, Pa) was placed in all patients using either the internal jugular or the subclavian approach. Pneumoperitoneum was established with CO_2 and maintained at 15 mm Hg in all patients. The laparoscopic approach required the standard 5 trocar (US Surgical, Norwalk, Conn) placements as previously described.[2] Occasionally, a sixth trocar site was used if a second liver retractor was needed for a patient with an extremely large left liver lobe. Hemodynamic parameters and blood gas values were recorded at 4 set points during the procedure: (1) after induction of anesthesia, (2) after the abdomen was insufflated with the patient supine, (3) with the patient in reverse Trendelenburg position (60% upright), and (4) after desufflation with the patient supine.

All measurements were uniformly taken 5 minutes after the change of position was established, to allow for equilibration and to avoid a potentially exaggerated reading immediately after a change.

All patients were given general anesthesia with narcotic-based agents (10 µg/kg loading dose of fentanyl followed by 2 µg/kg/min maintenance dose) supplemented with an inhalation agent, D-Desflurane 4%. The average time for the operation was 188 minutes; operation time ranged from 122 to 312 minutes, with a median of 181 minutes. The blood loss for all the cases was minimal, never exceeding 70 mL.

Statistical analysis was performed by paired *t* test between baseline values at induction and the 3 subsequent time points. Significance was defined as $P<.05$.

RESULTS

The average hemodynamic and blood gas values at each time point are summarized in **Table 2**. The most significant changes are presented in a graphic format in **Figures 1** and **2**.

Upon insufflation of the abdomen, systemic blood pressure, pulmonary artery pressure, central venous pressure, and pulmonary artery capillary wedge pressure increased significantly from the initial values. Both arterial and venous blood gases showed a decrease in pH and an increase in PCO_2 at this time. All other hemodynamic and blood gas values were essentially unchanged.

After changing to reverse Trendelenburg position, the pH, bicarbonate, and base excess remained significantly decreased compared with induction values. Arterial saturation and PO_2 were also significantly decreased but to a lesser extent. At this time, all hemodynamic parameters returned to or near their baseline equivalent.

After deflation of the abdomen with the patient in a flat, supine position, the cardiac index, blood pressure, pulmonary artery pressure, and pulmonary vascular resistance were significantly increased compared with induction values. Blood gases values showed further significant decreases in pH, bicarbonate, and base excess along with a significant increase in PCO_2 and venous PO_2.

COMMENT

Laparoscopic gastric bypass is gaining increasing popularity as a solution for the morbid obesity epidemic in the United States.[2] Laparoscopy has been shown to have potentially significant hemodynamic changes in high-risk cardiac patients during laparoscopic cholecystectomy.[12] Morbidly obese patients often have significant comorbid conditions. We sought to determine if laparoscopic gastric bypass, with its multiple patient position changes, could be performed safely on this patient population.

Surgeons who routinely operate on morbidly obese patients know that these patients are high risk for both surgery and anesthesia. Many of these patients, while of a young age, have a significant number of major comorbidities (ie, coronary artery disease, type II diabetes, cerebral vascular accident, restrictive lung disease, sleep apnea, and hypertension). Our study comprising 13 patients also showed a significant list of comorbid conditions, which are similar to those reported in other series.[1,2]

The Roux-en-Y gastric bypass operation was performed laparoscopically, maintaining the intra-abdominal pressure at 15 mm Hg. While this is the standard procedure reported in the literature, studies have also shown that there are potentially significant hemodynamic and respiratory changes that occur during laparoscopy.[13] Although most patients tolerate these changes well, studies have suggested that high-risk patients have a greater likelihood of adverse events related to elevated intra-abdominal pressure and could benefit from invasive hemodynamic monitoring.[14]

Our results are consistent with those obtained by other investigators studying the hemodynamic effects of laparoscopy, with a few noted exceptions. The increases seen in mean arterial pressure, systolic blood pressure, central venous pressure, and pulmonary artery capillary wedge pressure upon induction have been reported previously.[12,14,15] Indeed, the mean arterial pressure increase of 25% between induction and insufflation is consistent with other studies.[12,14,15]

Unlike other studies,[12,14,15] where the total peripheral resistance increased significantly, up to 79%, our study demonstrated only a 14% increase in total peripheral resistance, which was not significant. In addition, unlike other studies, ours saw no drop in cardiac index between induction and insufflation. In fact, the cardiac index increased from 3.55 to 3.85 L/min/m^2 between induction and insufflation. The increase, however, was not statistically significant.

Table 2. Changes in Hemodynamic and Respiratory Values During Laparoscopic Gastric Bypass

	Induction	Insufflation		Reverse Trendelenburg		Desufflation	
Induction	**Mean ± SD**	**Mean ± SD**	***P* Value**	**Mean ± SD**	***P* Value**	**Mean ± SD**	***P* Value**
pH							
Arterial	7.42 ± 0.04	7.38 ± 0.05	.004	7.38 ± 0.04	.009	7.33 ± 0.07	.001
Mixed venous	7.40 ± 0.04	7.36 ± 0.05	<.001	7.35 ± 0.004	.002	7.28 ± 0.06	<.001
P_{CO_2}, mm Hg							
Arterial	37.80 ± 5.61	40.91 ± 6.38	.008	39.87 ± 5.43	.14	42.59 ± 7.74	.04
Mixed venous	41.83 ± 4.72	45.83 ± 5.42	.002	43.80 ± 9.07	.002	47.84 ± 8.97	.04
P_{O_2}, mm Hg							
Arterial	138.80 ± 45.63	130.47 ± 38.15	.30	121.96 ± 40.76	.04	105.04 ± 19.78	.07
Mixed venous	42.75 ± 4.14	43.67 ± 5.26	.50	42.98 ± 5.21	.89	46.87 ± 4.31	.02
HCO_3, mEq/L							
Arterial	24.55 ± 1.85	24.15 ± 1.91	.32	23.55 ± 1.90	.001	22.56 ± 1.98	.02
Mixed venous	25.87 ± 1.59	25.45 ± 1.43	.28	24.92 ± 2.31	.02	22.91 ± 1.63	<.001
O_2 saturation, %							
Arterial	97.90 ± 2.21	97.55 ± 2.53	.19	97.18 ± 2.68	.04	96.90 ± 1.63	.24
Mixed venous	77.90 ± 4.68	76.50 ± 5.79	.34	75.40 ± 5.21	.14	78.33 ± 3.60	.61
Cardiac output, L/min	9.23 ± 1.50	10.00 ± 1.99	.09	9.74 ± 2.91	.41	10.93 ± 1.31	<.001
Cardiac index, L/min/m^2	3.54 ± 0.42	3.84 ± 0.71	.10	3.70 ± 0.83	.47	4.20 ± 0.39	<.001
Heart rate, beats/min	83.00 ± 8.00	85.15 ± 6.93	.58	86.61 ± 13.88	.41	84.61 ± 9.24	.79
Systolic blood pressure, mm Hg	117.76 ± 12.78	140.61 ± 15.73	<.001	118.61 ± 13.56	.84	132.30 ± 18.43	.04
Diastolic blood pressure, mm Hg	66.07 ± 11.17	83.38 ± 13.65	.002	67.69 ± 8.42	.57	77.00 ± 9.11	.009
Mean blood pressure, mm Hg	82.97 ± 11.40	102.64 ± 13.86	<.001	83.92 ± 10.72	.78	95.56 ± 10.55	.01
Central venous pressure, mm Hg	15.15 ± 3.55	21.53 ± 4.66	<.001	14.61 ± 3.77	.69	17.23 ± 4.08	.21
Systolic pulmonary artery pressure, mm Hg	36.61 ± 5.37	45.46 ± 5.30	<.001	36.15 ± 5.92	.79	45.46 ± 8.09	.10
Diastolic pulmonary artery pressure, mm Hg	22.23 ± 4.18	29.15 ± 5.61	<.001	20.92 ± 5.86	.37	26.61 ± 6.26	.07
Mean pulmonary artery pressure, mm Hg	27.02 ± 4.35	34.58 ± 5.26	<.001	26.00 ± 5.54	.49	32.89 ± 6.75	.03
Pulmonary artery capillary wedge pressure, mm Hg	19.76 ± 3.58	24.53 ± 4.66	.01	17.53 ± 2.84	.07	20.76 ± 2.74	.45
Total peripheral resistance, dyne·second·cm^{-5}	1545.11 ± 315.23	1747.77 ± 449.61	.14	1548.21 ± 349.54	.97	1493.95 ± 227.48	.60
Pulmonary vascular resistance, dyne·second·cm^{-5}	161.33 ± 56.59	212.48 ± 87.44	.13	188.19 ± 117.72	.45	229.07 ± 96.98	.02

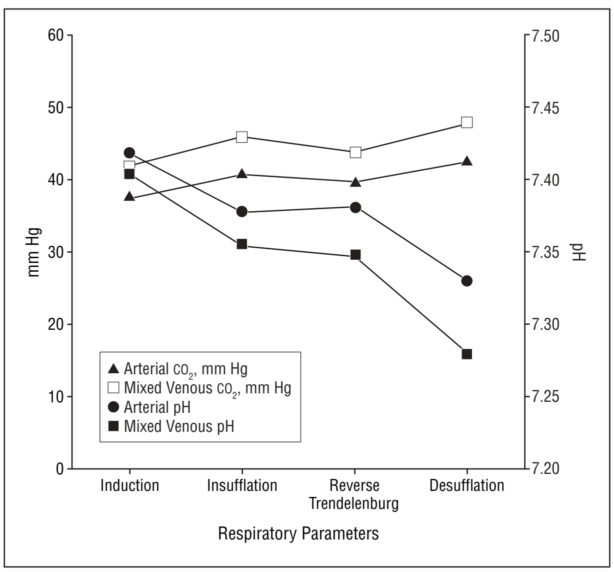

Figure 1. Significant respiratory changes during laparoscopic gastric bypass.

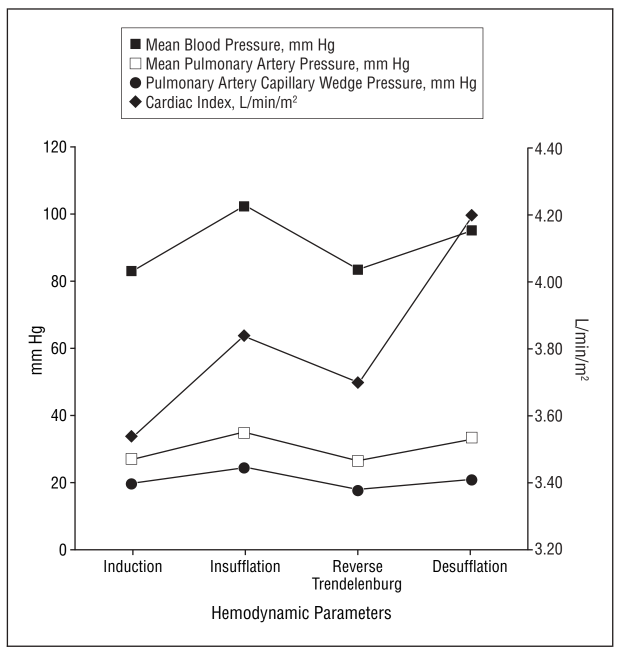

Figure 2. Significant hemodynamic changes during laparoscopic gastric bypass.

Decreased pH and increased P_{CO_2} during laparoscopy are reported in the literature.[16] The increased intra-abdominal pressure causing increased intrathoracic pressure is one explanation. Another potential causative factor could be CO_2 absorption from the peritoneum.[11,17,18]

Once the patients were placed in reverse Trendelenburg position, many of the hemodynamic changes that occurred after insufflation were reversed. The mean arterial pressure, blood pressure (systolic and diastolic), and total peripheral resistance decreased to the range noted prior to insufflation. The central venous pressure and pulmonary artery capillary wedge pressure actually decreased to levels lower than induction levels when the patients were placed in reverse Trendelenburg position. Although this could be explained by the effect of gravity causing decreased preload to the heart, there should be a concomitant drop in cardiac index, which we did not observe, as the heart rate remained essentially unchanged throughout the procedure. The cardiac index did decrease, albeit not significantly, after the patient was placed in reverse Trendelenburg, but it remained above its baseline value recorded after induction, even though pneumoperitoneum and intra-abdominal pressure remained unchanged.

It is interesting to note the blood gases results during the reverse Trendelenburg positioning. With the patient in this position, one would expect decreased diaphragm elevation and therefore decreased intrathoracic pressure transmitted to the lungs, resulting in a ventilation improvement. However, this was noted not to be the case. The PCO_2 increased compared with induction (although not significantly) and the pH remained significantly decreased as it had after insufflation. The trend of lowering pH and increasing PCO_2 continued throughout the procedure. This is probably explained by CO_2 absorption from the pneumoperitoneum, which has an additive effect as the surgery proceeds.[19]

The potentially adverse hemodynamic effects of increased intra-abdominal pressure have been reported elsewhere[20] and could be especially serious in the morbidly obese population. Laparoscopic procedures generally have less postoperative pain as compared with traditional surgery through large incisions. This decreased pain has been shown to lead to improved pulmonary function after laparoscopic surgery vs open surgery. This is especially helpful in the morbidly obese population, who often experience significant pre-operative pulmonary dysfunction.[1,21]

Laparoscopic gastric bypass surgery is associated with significant adverse hemodynamic and respiratory changes, which are well tolerated by most patients. However, like other high-risk patients undergoing laparoscopic surgery, laparoscopic gastric bypass candidates with significant cardiorespiratory comorbidities may benefit from invasive hemodynamic monitoring.

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