



Obesity: Physiologic changes and challenges during laparoscopy

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KEY WORDS

Obesity
Laparoscopy

Objective: The purpose of this report was to describe the evidence for the benefits of laparoscopic surgery in obese patients, to review the physiologic abnormalities that are associated with obesity, and to explore surgical techniques that will enable surgeons to perform laparoscopy successfully in obese patients.

Study design: This article is a review of the available literature on obesity, the physiologic changes that occur in obese patients, and the impact of these changes on laparoscopy outcomes.

Results: Obesity is associated with sudden death and a wide range of morbid conditions such as hypertension, atherosclerosis, angina, chronic obstructive disease, and diabetes mellitus. Recent studies have demonstrated that obese patients who undergo laparoscopy have shorter hospital stays, less postoperative pain, and fewer wound infections when compared with obese patients who undergo laparotomy. Laparoscopy patients also have fewer postoperative ileus and fevers.

Conclusion: With thorough preparation and careful preoperative evaluation, laparoscopy can be performed safely and is the preferred surgical method in obese patients.

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Obesity is defined commonly as a body mass index (BMI) $> 30 \text{ kg/m}^2$. Since 1960, the prevalence of obesity in the United States has increased steadily among genders, all racial groups, and all educational levels. In

2000, the reported prevalence of overweight adults (BMI, ≥ 25 - $\leq 30 \text{ kg/m}^2$) was 33.6% among those aged 20 to 74 years and the prevalence of obesity (BMI, $\geq 30 \text{ kg/m}^2$) more than doubled from 13.3% in 1960 to 30.9% in 2000.¹⁻³ In 2003, Ford et al⁴ reported that not only is obesity in the United States increasing but the waist circumference ratio also has shifted, which demonstrates a rapid increase in abdominal obesity. Annual medical spending attributed to overweight and obese patients was estimated to be \$92.6 billion in 2002.⁵ As this trend continues, obesity is likely to be an increasing challenge to medical providers, including gynecologists who perform laparoscopic surgery.

Presented at the Sixty-Sixth Annual Meeting of the South Atlantic Association of Obstetricians and Gynecologists, Boca Raton, Florida, January 18-21, 2004.

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General physiologic changes in the obese patient

Obesity is associated with various morbid conditions that include diabetes mellitus, hypertension, and hypercholesterolemia. Compared with normal weight adults, adults with a BMI >40 kg/m² have increased odds for having diabetes mellitus (odds ratio (OR), 7.37; 95% CI, 6.39-8.50), hypertension (OR, 6.38; 95% CI, 5.67-7.17), and hypercholesterolemia (OR, 1.88; 95% CI, 1.67-2.13). Obese adults are also more likely to have asthma (OR, 2.72; 95% CI, 2.38-3.12) and arthritis (OR, 4.41; 95% CI, 3.91-4.97).⁶ The Framingham study showed an association between angina, sudden death, and obesity.⁷ Other studies report a 50% to 100% increase in mortality rates because of cardiovascular causes. Given these observations, it is not surprising that life expectancy in obese female persons is shortened by as much as 8 years.^{8,9}

Increased body mass in obese patients leads to a variety of hemodynamic and cardiovascular changes with resultant physiologic abnormalities. In general, cardiac disease arises from cardiovascular adaptation to increased body mass and increased metabolic demand.¹⁰ Increased oxygen demand in turn leads to increased cardiac output, larger stroke volume, decreased vascular resistance, and increased cardiac work. Larger cardiac stroke volume and cardiac output causes hypertension and cardiomegaly. Autopsy studies have shown that obese patients can have 20% to 55% larger cardiac diameters, hypertrophied ventricles, and increased cardiac weight compared with nonobese persons.^{10,11} Other clinical studies consistently have demonstrated an increased risk of death that is associated with cardiac chamber dilation, ventricular hypertrophy, and cardiac failure that are caused by obesity. In addition, unexplained cardiac arrhythmias are also more common in obese patients.¹⁰⁻¹⁶

Obese patients are at additional risk for altered respiratory physiologic condition. Oxygen consumption and carbon dioxide production are more pronounced in obese patients. Excess body weight around the ribs, under the diaphragm, and intra-abdominally causes reduced chest wall compliance. Impeded chest wall expansion combined with increased oxygen demand and elevated pulmonary blood volume result in decreased lung compliance. This leads to lower expiratory reserve volume and decreased functional residual capacity (FRC).^{10,11} In dependent portions of the lungs, decreased FRC can fall within the closing volume and result in airway closure and subsequent ventilation/perfusion mismatch. The supine position in normal weight patients can reduce FRC by approximately 25%. Anesthesia reduces FRC by an additional 20%. In the obese patient, supine positioning and anesthesia can decrease to levels lower than closing capacity that

results in airway closure and hypoxemia.¹⁷ Soderberg et al¹⁸ demonstrated intrapulmonary shunting of 10% to 25% in obese patients compared with 2% to 5% in normal weight control subjects.

Gastric function may also be abnormal in obese patients. Since the 1970s, there have been reports that obese patients are more likely to have large gastric volumes, lower gastric pH, and delayed emptying, which places them at increased risk for gastric acid aspiration during surgery.^{19,20}

Pharmacokinetics should also be given special consideration in obese patients. Obese patients have a smaller than normal fraction of total body water, greater than normal adipose tissue content, and increased blood volume, volume distribution, and renal blood flow. Thus, drug distribution and effect may be different in this patient population and should be considered carefully before surgery.¹⁰

Surgical outcomes in obese patients who undergo laparoscopy

In past years, obesity was considered a relative contraindication for gynecologic laparoscopy because of the morbidity that is associated with obesity, difficulty with Verres needle placement, hindered manipulation of laparoscopic instruments, and the accumulation of fat in the omentum that often obstructs the operative field.²¹ However, more recent studies indicate that healthy obese patients are likely to benefit from laparoscopic surgery, assuming the technical challenges can be overcome.

Eltabbakh et al²² prospectively studied a cohort of 42 obese women, with BMIs between 28 and 60 kg/m², who underwent laparoscopic hysterectomy, bilateral salpingo-oophorectomy, and lymph node dissection for stage I endometrial carcinoma. In their cohort, only 7.5% of the patients were converted to laparotomy. The remaining 88.1% (37/42 patients) had the surgery performed laparoscopically. When this group of women was compared with 40 other women who had the procedures performed by laparotomy, the laparoscopic group had shorter hospital stay (2.5 vs 5.6 days; $P < .001$), less pain (32.3 vs 124.1 mg of pain medication; $P < .001$), and earlier return to normal activity. The only reported advantage to laparotomy was shorter operative time (134 vs 194 minutes in the laparoscopy group). Since this study was first published in 2000, several other studies with larger cohorts have reported on the safety of laparoscopy in obese patients. Conversion to laparotomy rates vary from 14% to 36% compared with 5% to 6% in nonobese patients, depending on the type of and indication for surgery. Despite this, obese patients who undergo laparoscopy have less postoperative ileus (0% vs 13.3%), fewer postoperative fevers (5.5% vs 31.1%),

and fewer wound infections (9% vs 22%) than obese patients who undergo laparotomy. It is now generally accepted that, in the hands of experienced surgeons, obesity is not a contraindication to laparoscopy.²³⁻³⁰ In fact, most authors agree that, except for the risk of conversion, laparoscopy is safe and effective and is the procedure of choice for healthy obese patients.

The impact of obesity on respiratory mechanics

At baseline, morbidly obese patients have reduced supine FRC, lower chest wall compliance, and increased carbon dioxide production. It was suspected initially that carbon dioxide pneumoperitoneum and the Trendelenburg position that is used in laparoscopy would lead to further cardiorespiratory compromise in these patients.³¹ Respiratory mechanics in obese patients were better characterized in a 2002 study that was conducted by Sprung et al.³¹ In this report, anesthetized morbidly obese patients (mean BMI, 46.6 kg/m²) and normal control subjects (mean BMI, 22.6 kg/m²) were studied in supine, Trendelenburg, and reverse Trendelenburg body positions before and after insufflation of the abdomen with carbon dioxide to a pressure of 20 mm Hg. Static compliance was 30% lower and inspiratory resistance was 68% higher in morbidly obese patients in the supine position. Pneumoperitoneum further reduced compliance in obese patients compared with normal weight control subjects. Interestingly, pulmonary artery oxygen levels were affected only adversely by increases in body weight and did not change significantly after the insufflation or repositioning of the patient into the Trendelenburg position. During anesthesia, obese patients in supine position required 15% higher minute ventilation to maintain normocarbia before insufflation. The authors concluded that the largest detrimental effect on respiratory mechanics is attributable to increased weight and supine positioning. Pneumoperitoneum adds to increased inspiratory resistance that requires higher minute ventilation, but oxygenation is not affected by pneumoperitoneum or Trendelenburg position. Therefore, less favorable respiratory mechanics in obese patients who undergo laparoscopy may have little impact on overall outcome.³¹ Those patients who tolerate the induction of anesthesia and supine positioning are likely to tolerate pneumoperitoneum and Trendelenburg position as well.

Preparation, positioning and recommended surgical techniques for laparoscopy in the obese patient

The best way to ensure safe and successful laparoscopy in obese patients is thorough extensive preoperative evaluation, patient counseling, and preparation.

Preoperative work-up

Preoperative evaluation should include a thorough cardiovascular and respiratory history. Patients should be assessed with an extensive review of the medical history for the presence of hypertension, smoking, sleep apnea or other obstructive pulmonary disease, and peripheral vascular disease.¹⁰

During the physical examination, the patient's blood pressure must be obtained with an appropriately sized blood pressure cuff. The patient should also be evaluated for evidence of peripheral vascular disease, skin changes, or ulcerations. Last, the airway should be carefully examined, because intubation difficulties can be caused by excessive fat around the face, a short neck, and limited movement of the jaw and neck.¹⁰ We highly recommend consultation with the anesthesia team and the development of a preoperative intubation plan.

Baseline laboratory screening must include blood count, serum electrolytes and glucose concentrations, and renal function tests.^{10,11} An electrocardiogram, chest x-ray, and arterial blood gas level are also recommended in the assessment of the patient's cardiopulmonary status. The electrocardiogram often can reveal signs of ischemia, arrhythmias, strain, and ventricular hypertrophy. The chest x-ray is adequate to evaluate heart size or other pulmonary abnormalities.^{10,17}

The routine use of pulmonary function tests is controversial.^{10,17} Some authors maintain that pulmonary function tests should be performed in all obese patients.¹⁰ We are not aware of any evidence to suggest that pulmonary function tests should be routine in healthy obese patients. Based on our experience, we recommend that pulmonary function testing be limited to obese patients with a history of smoking, sleep apnea, asthma, or other lung disease.

Extensive patient counseling is essential in morbidly obese patients. They need to understand the practical and technical difficulties that may be encountered by the staff and surgeons during laparoscopy (such as intravenous access and need for central lines, panniculus repositioning, and conversion to laparotomy). Patients must also understand that their recovery depends on early ambulation and avoidance of the supine position.^{11,32}

Panniculus and body type evaluation

Proper evaluation of the patient's panniculus and body type is crucial for determining intravenous access, trocar placement, and positioning during laparoscopy. Special attention must be paid to the distribution of the patient's weight (ie, increased waist circumference vs increased hip circumference). Patients with large adipose tissue centered on their waist are likely to be more

technically challenging than patients whose adipose is centered on the hips. In patients with large panniculi, trocar placement may be hindered not only by increased thickness but also by a lack of mobility. If the panniculus is soft and mobile, it can be repositioned easily with the use of traction with weights or tape.

During the preoperative evaluation, the panniculus should be lifted to identify the ischial spines, the xiphoid process, the costovertebral edge, and the bifurcation of the aorta in relation to the patient's umbilicus in the standing and supine positions. In obese patients, the umbilicus is often located 3 to 6 cm caudal to the aortic bifurcation.³³ Thus, the umbilicus cannot be used for the determination of trocar placement, and the surgeon must rely instead on the location of the other structures.

Preparation of the operating room and staff

In preparation for surgery, the operating room staff and anesthesia teams must be advised of the patient's weight. A surgical table that tolerates the patient's weight should be used, or 2 tables may be used together. Extra padding, blankets, sheets, and lifting devices are often needed for appropriate positioning of obese patients. Most operating rooms will also need to be equipped with a large blood pressure cuff and monitoring devices and large compression lower extremity stockings and pneumatic boots. Finally, central vascular access materials should be available for cases in which peripheral intravenous access fails.

Positioning

In our review of the literature, we found no studies on positioning obese patients during laparoscopy. The following recommendations are made on the basis of our institutional experience where we performed >680 laparoscopic hysterectomies between 1998 and 2002. Approximately 28% of our patients are morbidly obese, with mean BMIs >35 kg/m². Our conversion and complication rates are very low and consistent with previously published reports.²³⁻³⁰

To decrease the risk of positioning injury, we suggest the use of padded stirrups with extra padding around the ankles and knees (and other visible pressure points) after compression devices have been placed. In patients with large breast mass, we use multiple towels behind the shoulder blades to elevate the head above the patient's chest. This facilitates intubation and access to the airway during laparoscopy. We also use a gel pad that is positioned under the patient to decrease pressure on the lower back and prevent the patient from slipping. We also recommend that the arms be tucked gently at the patient's side in the supine or "military" position.

This allows the surgeon to be positioned adequately at the patient's side without interference from the arms, as can happen when they are kept in the extended position. When the arms are tucked, padded shoulder blocks can be placed at the acromioclavicular joint to prevent the patient from slipping while in the Trendelenburg position. To minimize the risk of brachial plexus injury, we suggest using the shoulder blocks only when the arms are in the tucked position.

The panniculus can be repositioned for ease of instrumentation, as long as the previously described body landmarks have been identified. Depending on the mobility of the pannicular tissue, it can either be taped or weighted towards the lower portion of the body. We use clamps, sterile gauze, and 2.5-lb orthopedic weights. The goal is to put gentle traction on the tissue to move it out of the way in a caudad direction and thin the abdominal wall. Too much traction should be avoided because this can tear or necrose tissue.

Throughout the case the surgeon, anesthesiologist, and nursing staff should survey the patient's position to ensure continued proper placement of the arms, legs, padding, and compression devices.

Premedication

Obese patients are good candidates for preoperative antibiotics. Studies have shown that prophylactic antibiotics are effective in reducing the incidence of wound infection from 21% to 4%.^{34,35} H₂-receptor blocking agents should be administered 60 to 90 minutes before surgery to reduce gastric pH.^{10,19,20} Preoperative β -blockers may be considered in patients with hypertension but without evidence of reactive airway disease, cardiac conduction system disease, or other contraindications to β blockade.

Access, pneumoperitoneum, and intraoperative technique

One of the major technical problems in obese patients is access to the abdominal cavity. In nonobese patients, it is suggested that the Verres needle and trocar be placed at 45 degrees from the horizontal. However, in obese patients, insertion may be more likely to be successful with a 90-degree angle instead. This angle may be used safely in obese patients because of increased abdominal wall thickness and the location of umbilicus, which is caudal to the aortic bifurcation.^{33,36} The saline drop test can be used for confirmation of intraperitoneal placement of the Verres needle. An extra-long Verres needle can sometimes be helpful, as can open laparoscopy and left upper quadrant entry.³⁶ Grasping the abdominal wall manually can be difficult in obese patients; the use of towel clips may make this process easier, but it can

also increase the distance from the skin to the fascia by pulling the skin away from the fascia. Alternatively, the skin incision can be extended to the fascia, which can then be grasped and elevated, thereby eliminating the passage of the needle through the thick subcutaneous tissue.³⁶ Transvaginal and transuterine insertion of the Veress needle have also been described but rarely are used.^{36,37}

Trocar should be placed angled towards the operative site to avoid torquing the instruments and to prevent slippage. They may also be stitched in place or longer cannulas may be used. Additional ports may be necessary.³⁶ At our institution, we routinely use a left upper quadrant port in addition to the umbilical and lower quadrant ports. We also recommend using an oral-gastric tube to aspirate stomach contents before the placement of the left upper quadrant port and throughout the case.

Most importantly, before proceeding with the surgery, we propose a simple test, which is known at our institution as the "tilt test." Once the patient is intubated and appropriately positioned, we suggest placing the patient in steep Trendelenburg for 2 to 5 minutes while observing the patient's cardiac and respiratory status. If the patient tolerates this position, the test should be repeated after insufflation of pneumoperitoneum. A patient who is able to remain normotensive and who maintains inspiratory pressures at 30 to 40 mm Hg during the "tilt test" before and after insufflation is likely to do well during laparoscopy.

To improve visualization during the procedure, the use of shoulder blocks and a gel pad will allow for the Trendelenburg position without the patient sliding off the table. When pelvic surgery is being done, excessively fatty omentum may be draped over the dome of the liver and kept out of the surgical field. Long instruments and extra ports may also facilitate the manipulation of the bowel to allow better visualization.

Postoperative care

General complications after laparoscopic surgery in obese patients include hypoxemia because of diminished FRC and atelectasis. These pulmonary complications may be avoided by the use of supplemental oxygen, aggressive pulmonary care, and semirecumbent position instead of supine position.¹⁷ Abdominal pain must be avoided because it can further restrict ventilation and prevent ambulation. Regional anesthesia for postoperative pain control is an excellent choice in obese patients.

Pulmonary emboli occur in 5% to 12% of obese patients who undergo surgery.¹⁷ It is generally accepted that obese patients should have sequential compression devices placed on the lower extremities or prophylactic

subcutaneous anticoagulation to prevent these potentially fatal complications.

Comment

Obesity is becoming more common in the United States, and laparoscopic surgeons are likely to face an increasing number of obese patients. Contrary to previous reports, laparoscopy is not contraindicated in healthy obese patients. In fact, obese patients experience less pain, quicker recovery, and fewer postoperative complications after laparoscopy compared with laparotomy.

Laparoscopy in these patients should involve a careful preoperative evaluation, ample preparation, and patient counseling. Several techniques are available to facilitate laparoscopy in obese patients, and conversion rates to laparotomy are low. During the postoperative period, aggressive pulmonary care and pain control, ambulation, and deep venous thrombosis prophylaxis are recommended. To ensure successful surgical outcomes, surgeons must have a thorough understanding of physiologic changes in obesity and the surgical techniques to be used during laparoscopy.

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