

Laparoscopic Cholecystectomy in a Cardiac Transplant Candidate with an Ejection Fraction of Less than 15%

Perry E. Jones, MD, Samuel C. Sayson, MD, David C. Koehler, MD

ABSTRACT

Background and Objectives: Laparoscopic procedures are becoming increasingly popular, even in the severely ill patient. We present a case of a cardiac transplant candidate with an ejection fraction of less than 15% who underwent a laparoscopic cholecystectomy. This is the first case in which intraoperative hemodynamic measurements were recorded in a patient with cardiopulmonary disease this severe.

Methods: The patient underwent the procedure while measurements were made at crucial intervals (baseline, with incremental insufflation, reverse Trendelenberg, at desufflation) using a pulmonary artery catheter, transesophageal echocardiography with fractional area measurements, radial arterial line, as well as standard monitoring.

Results: This patient showed hemodynamic changes consistent with a person without severe heart disease. There was a rise in mean arterial and systemic vascular resistance with insufflation to 10 mm Hg, which was further exaggerated by reverse Trendelenberg.

Heart rate and pulmonary artery wedge pressure increased slightly. The cardiac output and fractional area change declined minimally.

Conclusions: We conclude that if a patient with congestive heart failure is medically optimized, and intra-abdominal pressures and surgical times are minimized, laparoscopic cholecystectomy may be performed with minimal risk to the patient.

Key Words: Laparoscopy, Cardiopulmonary disease, Planimetry, Hemodynamics.

INTRODUCTION

Increasingly, laparoscopic procedures are being utilized to decrease postoperative pain and length of hospital stay. The one group in which laparoscopy may have adverse effects, that outweigh the potential benefits, is the patient with severe cardiopulmonary disease. There has not been a case reported of a laparoscopic procedure with hemodynamic measurements on a patient with an ejection fraction of less than 20%. We present a case of a patient with end-stage cardiac disease with an ejection fraction estimated at less than 15% who underwent laparoscopic cholecystectomy prior to becoming eligible for cardiac transplant.

CASE REPORT

A 59 year old woman presented with end-stage idiopathic cardiomyopathy. The patient had asymptomatic cholelithiasis and was to undergo a laparoscopic vs. open cholecystectomy prior to becoming eligible for cardiac transplant.

An echocardiogram two weeks prior to admission revealed a normal sinus rhythm, global hypokinesis with an ejection fraction of less than 15%; valvular abnormalities included mild mitral and tricuspid regurgitation. A right and left cardiac catheterization one week prior to this admission confirmed the above, and revealed pulmonary hypertension with pulmonary artery pressures of 72/35. The mean pulmonary artery pressure improved to 26 mm Hg with sodium nitroprusside.

Pertinent medications included metropolol 6.25 mg po BID, digoxin 0.125 mg po q d, enalapril 20 mg po BID, furosemide 40 mg po q d, and coumadin 4 mg po q d.

Physical exam was without evidence of congestive heart failure. Laboratory evaluation was within normal limits.

Upon arrival in the operating room, the patient was connected to standard monitoring (i.e., 5-lead EKG, pulse oximetry, arterial blood pressure, capnography, and body temperature). Prior to induction, a radial arterial line and oximetric pulmonary artery catheter were placed through the right internal jugular vein. Induction was accomplished with Etomidate 0.3 mg/kg, fentanyl 10 mcg/kg, and succinylcholine 1.0 mg/kg. After entubation, a Hewlett-Packard biplanar transesophageal echocardiography probe

Anesthesia and Operative Service
Department of Surgery
Brooke Army Medical Center

Address reprint request to: Perry E. Jones, MD, Anesthesia and Operative Service, Department of Surgery, Brooke Army Medical Center, 3851 Roger Brooke Drive, Ft. Sam Houston, TX 78234-6200. Telephone: (210) 916-2118, Fax: (210) 916-0268

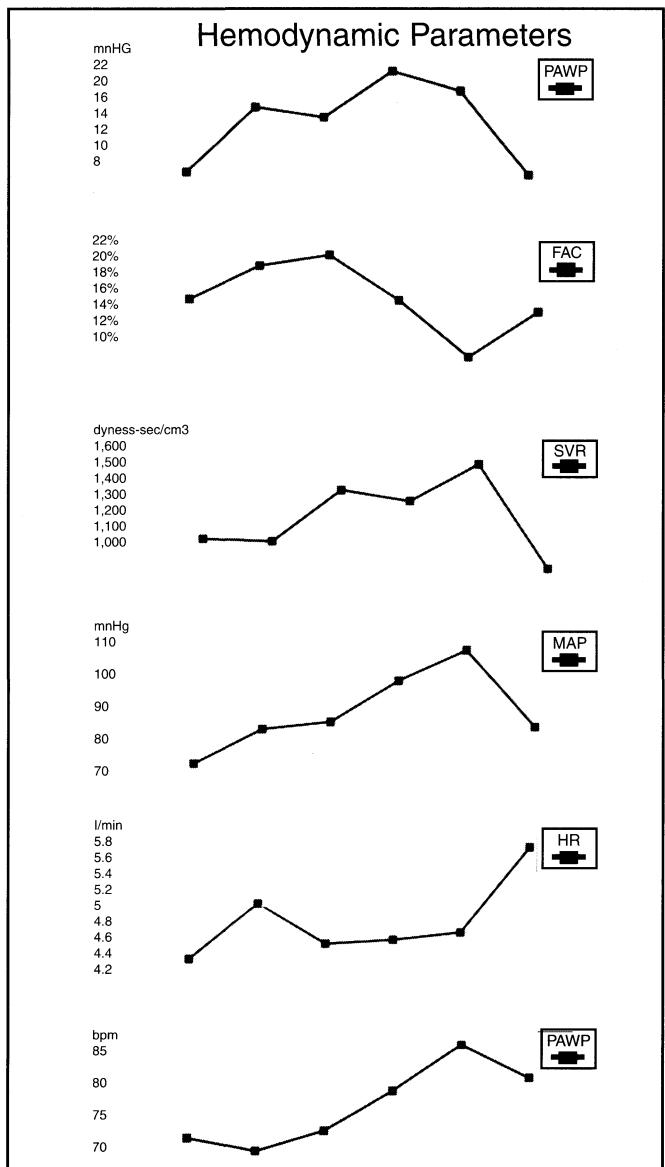


Figure 1. Pulmonary Artery Wedge Pressure (PAWP), Fractional Area Change (FAC) by transesophageal echo., Systemic Vascular Resistance (SVR), Mean Arterial Pressure (MAP), Cardiac Output (CO), Heart Rate (HR) recorded at 5 minutes after an intra-abdominal pressure of 5 mm Hg, 10 mm Hg, assuming 10 degrees reverse Trendelenberg (RT), and on return to supine and desufflation of the abdomen.

(Model #21362A) at 5.0 MHz frequency was positioned to obtain a transgastric short axis view of the midpapillary level of the left ventricle.

Anesthesia was maintained with isoflurane at 0.35-0.45%, nitrous oxide 50% in oxygen 50%. Muscle relaxation was

accomplished with vecuronium maintaining 1 of 4 twitches on a train-of-four. Ventilation was controlled with the pH ranging between 7.35-7.40 and pCO_2 40-48 mm Hg. The case lasted 42 minutes. Blood loss was minimal, and the patient received a total of 10ml/kg of Lactated Ringer's intravenously.

Measurements were taken pre-induction, immediately post-induction, five minutes after pneumoperitoneal insufflation to 5 mm Hg, five minutes after insufflation to 10 mm Hg, five minutes after 10 degrees of reverse Trendelenburg position, and five minutes after return to the supine position and desufflation.

Parameters measured included heart rate, blood pressure, pulmonary artery pressures, cardiac output, pulmonary artery occlusion pressure, and central venous pressure. With each change in table position, pressure transducer height was adjusted to maintain a constant phlebostatic axis with respect to the right atrium. Videotaped recordings of the intraoperative echocardiogram were used to evaluate for wall motion abnormalities and to calculate left ventricular fractional area change postoperatively. Analysis was performed via manual planimetry by a skilled observer (DCK) blinded to intraoperative events. End-diastolic (EDA) and end-systolic areas (ESA) were planimetered on two consecutive cardiac cycles and averaged using the leading edge of the left ventricular endocardial border. EDA was determined by the greatest cross-sectional area obtained at the peak of the electrocardiogram R wave. The ESA was determined by the smallest left ventricular area obtained. Percent ejection fraction area (%EFA) was determined from the formula $\%EFA = (EDA-ESA/EDA) \times 100$.

DISCUSSION

Laparoscopic cholecystectomy is becoming an increasingly popular alternative to open cholecystectomy. The laparoscopic procedure combines the benefit of completely removing the gallbladder with the advantages of a shorter hospital stay, less pain, and less chance of postoperative ileus compared to the open cholecystectomy.¹ Pulmonary function is better preserved postoperatively, resulting in better oxygenation and ventilation.

These advantages should provide theoretical benefits for patients with heart disease requiring cholecystectomy; however, the use of peritoneal insufflation, CO_2 as the insufflating gas, and reverse Trendelenburg position necessary for a laparoscopic cholecystectomy have been shown to cause significant alterations in hemodynamic parameters. Some of these changes might discourage the use of laparo-

scopic cholecystectomy in high-risk cardiac patients, especially those with very low ejection fractions.

Laparoscopy has been well studied, especially in the healthy gynecologic patient. The three variables that effect the patient's hemodynamic parameters are insufflation, the use of CO₂ as the insufflant, and patient position.

The extent of the cardiovascular changes associated with creation of pneumoperitoneum depends on the intra-abdominal pressure (IAP) attained. With our patient, the IAP was limited to 10 mm Hg. Because of her thin body habitus, this limitation was not difficult to accomplish, yet still provided adequate visualization for surgery. In healthy patients undergoing laparoscopic cholecystectomy, the usual IAP is 15 mm H₂O. At this IAP the filling pressures and mean arterial pressure (MAP) may increase, but cardiac output (CO) typically remains unchanged.^{2,3} In patients with severe heart disease, however, changes in hemodynamic parameters have varied between investigators. Iwase et al.,⁴ utilizing IAPs of 12 mm Hg, have described hemodynamic changes similar to our patient. However, Safran et al.,⁵ using 15 mm Hg IAPs, noted that several high-risk cardiac patients experienced decreases in CO and SvO₂. They felt that these patients were relatively volume depleted preinsufflation, then worsened with a further decrease in preload when insufflation was applied. Portera et al.⁶ similarly describe a significant fall in cardiac index (CI) and stroke volume (SV) despite preoperative optimization of preload and cardiac output using fluid boluses. Neither Safran nor Iwase reported any intraoperative cardiac complications or any increase in postoperative morbidity or mortality. Portera, on the other hand, reported two cases of postoperative congestive heart failure. He observed a progressive decrease in CI, SV, and left ventricular stroke work following desufflation in these patients; but, he could not identify any obvious feature preoperatively, or at the time of insufflation, that might predict which patients might be at risk.

The hemodynamic course of our patient was uneventful (**Figure 1**). At 10 mm Hg, our patient had changes similar to a healthy patient, documented by an increase in MAP and pulmonary artery wedge pressure (PAWP); end diastolic volume (estimated as End-Diastolic Area - EDA) and CO remained unchanged. Systemic vascular resistance (SVR) also increased with insufflation. With our patient's complicated preoperative course, consisting of two admissions within four weeks for CHF, one would have expected her to be relatively volume depleted and as such respond with an increase in BP and HR. Prior to desufflation, the most unusual finding was the decrease in echocardiographic fractional area change (FAC) to 12%; this finding mirrors (and is most probably explained by) a peak increase in SVR. Following desufflation, all hemodynamic

parameters corrected in an appropriate fashion: increased stroke volume secondary to improved preload, decreased SVR (reduced afterload) with subsequent increase in cardiac output, and a decrease in heart rate.

The use of CO₂ as the insufflant did not place our patient at risk. Hypercarbia over 50 mm Hg in healthy patients causes myocardial depression and is a direct vasodilator; as a result, there is a decrease in CO, SVR, and pH.⁷⁻¹¹ Hypercarbia at levels less than 50 mm Hg has been shown to produce minimal hemodynamic effects.⁷⁻⁹ In patients with ischemic heart disease, PaCO₂ levels of 55-65 mm Hg resulted in an increase in systolic BP, HR, and CO.⁸ There was also a two to threefold increase in plasma catecholamine concentrations which suggests hypercarbia stimulates the sympathetic nervous system in this group of patients.⁸ We had no difficulty maintaining a PaCO₂ below 50 mm Hg in our patient; her lean body habitus was a contributing factor in our ability to maintain adequate ventilation. It is unclear whether her upward trend in HR, MAP, and SVR (suggestive of an increase in sympathetic stimulation) was related to the mild hypercarbia present, or to a drop in preload (see EDV, **Figure 1**).

Theoretically, the change to reverse Trendelenburg should cause cardiovascular compromise in the form of decreased venous return (VR) and CO. This decline may be offset by a decrease in afterload leading to an insignificant change in CO in otherwise healthy patients.

The study done by Safran looking at laparoscopic cholecystectomy in patients with severe cardiac disease utilized an IAP of 15 mm Hg and maintained normal end-tidal CO₂ (ETCO₂).⁵ The reverse Trendelenburg position was used in most of the 15 ASA Physical class III and IV patients evaluated. Unfortunately, hemodynamic parameters were not measured after the establishment of pneumoperitoneum independently of assuming reverse Trendelenburg. Also, there was no mention as to the degree of reverse Trendelenburg attained. A significant increase in MAP and SVR accompanied by a decrease in CO was found. These changes were thought to be due to aggressive treatment of congestive heart failure preoperatively, thus leading to a volume depleted patient with little intravascular volume reserve. In our patient, the only significant finding on assuming 10 degrees of reverse Trendelenburg position was an increase in the SvO₂ from 83% to 90%. This was most likely due to improved respiratory mechanics. This elevation in SvO₂ came in conjunction with a decline in ETCO₂ from 38 mm Hg to 30 mm Hg, adding further credence to the improvement in pulmonary function as the probable mechanism.

We evaluated transesophageal echocardiography (TEE) as an aid to monitoring this patient during laparoscopic chole-

cystectomy. Following the establishment of pneumoperitoneum and assumption of the reverse Trendelenburg position, the FAC via TEE was assessed as an indirect measure of ejection fraction (EF). No significant changes or trends could be identified utilizing this technique, perhaps due to subtle changes in wall thickening and short axis diameters in a patient with a low EF. Portera et al.⁶ were also unable to find benefit of TEE use as an intraoperative monitor in laparoscopic patients with cardiac disease.

We conclude from this case that laparoscopic cholecystectomy can be performed safely in patients with severe cardiac disease and ejection fractions less than 20%. Under these circumstances it is imperative that appropriate monitoring be utilized, and IAP, reverse Trendelenburg and surgical time minimized.

References:

1. Cunningham AJ, Brull SJ. Laparoscopic cholecystectomy. Anesthetic implications. *Anesth Analg.* 1993;76:1120-1133.
2. Liu SY, Leighton T, Davis I, et al. Prospective analysis of cardiopulmonary responses to laparoscopic cholecystectomy. *J Laparoendosc Surg.* 1991;1:241-246.
3. Marshall RL, Jebson PJR, Davie IT, Scott PB. Circulatory effects of carbon dioxide insufflation of the peritoneal cavity for laparoscopy. *Br J Anaesth.* 1972;44:680-684.
4. Iwase K, Takenaka H, Yagura A, et al. Hemodynamic changes during laparoscopic cholecystectomy in patients with heart disease. *Endosc.* 1992;24:771-773.
5. Safran D, Sgambati S, Orlando R. Laparoscopy in high-risk cardiac patients. *Gynecol Obstet.* 1993;176:548-554.
6. Portera CA, Compton RP, Walters, DN, Browder IW. Benefits of pulmonary artery catheter and transesophageal echocardiographic monitoring in laparoscopic cholecystectomy patients with cardiac disease. *Am J Surg.* 1995;169:202-207.
7. Safran DB, Orlando R III. Physiologic effects of pneumoperitoneum. *Am J Surg.* 1994;167:281-286.
8. Rasmussen JP, Danchot PJ, DePalma RG, et al. Cardiac function and hypercarbia. *Arch Surg.* 1978;113:1196-2000.
9. Smith I, Benzie RJ, Gordon NL, et al. Cardiovascular effects of peritoneal insufflation of carbon dioxide for laparoscopy. *BMJ.* 1971;3:410-411.
10. Sharma DC, Brandstetter RD, Brensilver JM, Jung LD. Cardiopulmonary physiology and pathophysiology as a consequence of laparoscopic surgery. *Chest.* 1996;110:810-815.
11. Liu, N, Darmon P, Saada M, et al. Comparison between radionuclide ejection fraction and fractional area changes derived from transesophageal echocardiography using automated border detection. *Anesthesiology.* 1996;85:468-474.

The opinions or assertions contained herein are the private views of the authors and are not to be construed as reflecting the views of the Departments of the Army or Defense.