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Laparoscopic Cholecystectomy in a Patient With a Biventricular Cardiac Assist Device

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ABSTRACT

Evaluation and management of abdominal pathology in patients with ventricular assist devices is likely to become increasingly important as the utilization of these devices expands. Ventricular assist devices represent a class of intracorporeal or paracorporeal mechanical devices that augment cardiac output in patients with congestive heart failure. Patients with ventricular assist devices supporting both right and left ventricles (biventricular assist devices) are uniquely challenging to the general surgeon because these devices restrict direct access to the abdominal cavity and because of the perioperative implications of biventricular heart failure. We describe herein the first reported successful laparoscopic cholecystectomy in a patient with a paracorporeal biventricular assist device. Cholecystectomy was performed in this patient for acute cholecystitis that occurred while the patient was awaiting heart transplantation. Our results add weight to the small body of evidence that laparoscopy is well tolerated in ventricular assist devices patients. The unique aspects of the biventricular assist device patient make laparoscopic abdominal intervention particularly suitable in this patient population.

Key Words: Ventricular assist device, Laparoscopy, Cholecystectomy.

INTRODUCTION

Ventricular assist devices (VADs) have become an important modality in the treatment of congestive heart failure. The most common application of VADs is as a bridge to transplantation in patients with end-stage heart failure. Less commonly, VADs can serve as a bridge to recovery in patients with potentially reversible acute heart failure. Recent studies also support the use of VADs as destination therapy, in which VADS are permanently implanted as an alternative to heart transplantation. The expanding application of VADs makes it increasingly likely that general surgeons will encounter patients with these devices. We describe herein the presentation and management of acute cholecystitis in a patient with VADs supporting both right and left ventricles (BiVAD). This patient ultimately was treated by laparoscopic cholecystectomy, which has not been previously reported in a patient with a BiVAD. This article describes the complexities inherent in diagnosing and treating abdominal conditions in patients with VADs. A brief review of VAD technology and abdominal surgery in VAD patients is also provided.

Several types of VADs are FDA approved for clinical use in the United States. Devices vary in their biomechanical design, biomaterials, and drive mechanism. The Thoratec paracorporeal VAD System (Thoratec Corporation, Pleasonton, CA), which was utilized in our patient, is a pneumatically driven device that has an effective stroke volume of 65 mL and can deliver pulsatile blood flows of 1.3 L/min to 7.2 L/min. This VAD consists of 3 components: a blood pump that acts as a prosthetic ventricle; 2 cannulae that connect the blood pump to the heart and great vessels; and a drive console that powers the pump pneumatically **(Figure 1)**. The pump is considered paracorporeal because the pump chamber itself resides outside the body and delivers flow through transcutaneous cannulae that enter the body 2 cm to 4 cm below the costal margin. Separate inflow and outflow cannulae are required for each VAD device. Thoratec paracorporeal VADs can be used to support the left ventricle, right ventricle, or both ventricles (LVAD, RVAD, and BiVAD, respectively).

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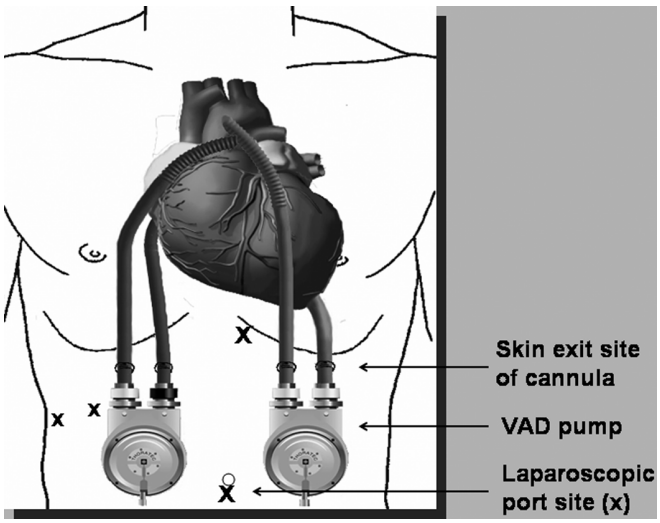

Figure 1. Schematic of a Thoratec paracorporeal BiVAD demonstrating side-by-side VADs, each supporting one ventricle. Port sites for laparoscopic cholecystectomy are indicated (x).

Figure 2. Postoperative appearance of a patient with a Thoratec paracorporeal BiVAD. Transcutaneous cannulae exit the abdominal wall approximately midway between the sternotomy incision and umbilicus.

METHODS

A 54-year-old male underwent reoperative coronary artery bypass grafting and was unable to be weaned from cardiopulmonary bypass despite maximal inotropic and vasopressor support as well as intraaortic balloon pump counterpulsation. A Thoratec paracorporeal pneumatic VAD was implanted to support the left ventricle (LVAD), followed by successful weaning from bypass. Due to progressive right heart failure, he subsequently required additional placement of a Thoratec VAD to support the right ventricle (RVAD) 48 hours later **(Figure 2)**. His early postoperative course was remarkable for renal failure, requiring continuous renal replacement therapy and shock liver. Kidney and liver function returned to normal by 3 weeks postoperatively, and he was able to tolerate enteral nutrition and to engage in physical therapy. He was fully anticoagulated with coumadin (international normalized ratio 2.5 to 3.5) and aspirin according to a standard protocol.

Fifty-four days after BiVAD placement, the patient developed right upper quadrant pain, nausea, and vomiting. Physical examination revealed right upper quadrant tenderness in the area of one of the RVAD cannula exit sites. A computed tomographic (CT) scan of the abdomen was unremarkable, and an abdominal ultrasound demonstrated gallstones. Both studies were technically limited due to the position of the overlying device. On HIDA scan, the gallbladder was not visualized after 24 hours, and the diagnosis of acute cholecystitis was made. The patient had worsening pain despite antibiotics and required a cholecystectomy. Percutaneous cholecystostomy was felt to be contraindicated because of the risk of VAD infection resulting from a percutaneous drain in the vicinity of the RVAD cannula.

In preparation for surgery, anticoagulation was reversed with fresh frozen plasma. The paracorporeal VAD components were wrapped in sterile plastic and draped within the operative field. Laparoscopic ports were placed in standard fashion with each of 2 right subcostal ports placed lateral to the RVAD pump **(Figure 1)**. Pneumoperitoneum was maintained by using carbon dioxide at a maximal pressure of 15 mm Hg. During surgery, stable LVAD flows of 5 L/min to 6 L/min and RVAD flows of 4 L/min to 5 L/min were maintained with no decrease in blood pressure or filling pressures.

Intraoperative findings were consistent with acute calculous cholecystitis. Laparoscopic cholecystectomy was performed, and argon beam coagulation was utilized to control extensive bleeding from the gallbladder fossa. Total operating time was 45 minutes. Anticoagulation was withheld postoperatively, but the international normalized ratio rose to 3.3 and the patient developed postoperative bleeding requiring relaparoscopy on postoperative day one. Bleeding at one of the 5-mm port sites was identified and corrected with suture ligation. The remainder of the postoperative course was uneventful. The patient underwent successful BiVAD removal and heart transplantation after 101 days of VAD support.

Table 1.
FDA-Approved Ventricular Assist Devices

Device	Potential Support Options†	Position
Thoratec VAD System*	RVAD, LVAD, or BiVAD	Paracorporeal
Thoratec IVAD*	RVAD, LVAD, or BiVAD	Intracorporeal
Heartmate LVAS*	LVAD	Intracorporeal
Novacor LVAS†	LVAD	Intracorporeal
Abiomed BVS 5000‡	LVAD, RVAD, or BiVAD	Paracorporeal

*Thoratec Corporation, Pleasanton, California.

†RVAD=right ventricular assist device; LVAD=left ventricular assist device; BiVAD=biventricular assist device.

‡Abiomed Corporation, Danvers, Massachusetts.

DISCUSSION

This represents the first reported laparoscopic cholecystectomy in a patient with a BiVAD. In the current case, a laparoscopic approach was ideal because of the positioning of the BiVAD **(Figure 2)**. Biventricular paracorporeal devices like the Thoratec device described here obscure both upper abdominal quadrants and largely preclude subcostal incisions. A vertical midline laparotomy would be possible with careful attention to positioning and draping of the device, but the risk of exposing the pump components to enteral or infected material and causing device infection would remain. Laparoscopy, however, can be performed with minimal disturbance of paracorporeal pump devices and little risk of device contamination. Other potential benefits of laparoscopy including decreased postoperative pain and decreased wound complications have obvious appeal in this population.

Undertaking abdominal surgery in the VAD patient must be done with an understanding of VAD position and function. Paracorporeal devices like the Thoratec VAD System utilize extraanatomical pumps and trancutaneous cannulae. In contrast, intracorporeal devices like the Heartmate (Thoratec Corporation, Pleasanton, CA) or Novacor LVAS (World Heart Corporation, Oakland, CA) are implanted either inside the peritoneal cavity or within the rectus sheath. Intracorporeal devices rely on transcutaneous drive lines for power, but the pump itself and pump cannulae passing to the mediastinum are contained completely within the body. Factors that influence the choice between paracorporeal and intracorporeal devices include body habitus, the need for univentricular versus biventricular support, expected duration of support, and surgeon preference. Totally implantable devices that have no external components are under investigation. A comparison of commonly utilized VADs that are FDA-approved for bridge-to-transplant, bridge-to-recovery, or destination therapy is provided in **Table 1**. With any VAD, contamination of the device, drive lines, or pump pocket must be avoided, as infection is the leading cause of morbidity and mortality in VAD patients. In addition, if the cannulae cross the diaphragm inside the peritoneal cavity, risk is present of pneumopericardium or tension pneumothorax during abdominal insufflation.

Table 2.
Reported Series of Abdominal Surgery in Patients With Ventricular Assist Devices

Study	No. of Pts.	Type of Device*	Type of Surgery (n)	Complications (n)
Votapka[1] 1994	3	PC LVAD	Open cholecystectomy (2), Laparoscopic cholecystectomy (1)	Bleeding (1/3), Early death (1/3)
Goldstein[2] 1995	1	PC LVAD	Plication gastric ulcer	Hypotension
Prendergast[3] 1996	1	PC BiVAD	Diagnostic laparoscopy	None†
Aleksic[4] 1998	1	IC LVAD	Laparotomy, small bowel resection	None
Schmid[5] 2001	11	IC LVAD	Open cholecystectomy alone (4) or combined with bowel resection or cecostomy (3) Open ileostomy or cecostomy (3) Open bowel resection (1)	Bleeding (6/11)
Nissen 2004	1	PC BiVAD	Laparoscopic cholecystectomy	Bleeding

*PC=paracorporeal; IC=intracorporeal; LVAD=left ventricular assist device; BiVAD=biventricular assist device.

†Support withdrawn and patient died shortly after surgery.

To date, only a few reports have been published of abdominal surgery in patients with VADs.[1–5] These reports are summarized in **Table 2**. The majority of these cases were open explorations for complications directly attributable to cardiopulmonary bypass or splanchnic ischemia. The most common reported postoperative surgical complication in these collective reports was bleeding, similar to that seen in the patient described herein. This risk arises from the requirement for anticoagulation to prevent VAD-related thromboembolic events. Among these reports, only 2 are prior reports of laparoscopy in VAD patients. Votapka and others[1] reported successful laparoscopic cholecystectomy in a patient with univentricular support, and Prendergast and others[3] reported the use of brief diagnostic laparoscopy in a moribund patient with BiVAD support. The current report demonstrates that more prolonged therapeutic laparoscopy is also possible in the BiVAD patient. Similar to these prior reports, we found that laparoscopy was well tolerated and that abdominal insufflation did not produce hemodynamic instability.

Evaluation of the abdomen in the VAD patient should consider the same differential diagnosis as any patient previously undergoing cardiopulmonary bypass, including pancreatitis, acute cholecystitis, ischemic bowel, perforated ulcer, and diverticulitus. In addition, transcutaneous cannulas and drivelines may produce musculoskeletal symptoms that may mimic intraabdominal pathology. Standard imaging modalities, such as CT scan and ultrasound, may be nondiagnostic in the VAD patient because of interference by overlying devices. Our report and the few prior reports of laparoscopy in VAD patients support the expanded use of diagnostic and therapeutic laparoscopy in this patient group. Careful attention to device location and function, perioperative anticoagulation and postoperative bleeding risk is paramount in any anticipated abdominal intervention in the VAD patient.

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