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Laparoscopic procedures in patients with cardiac ventricular assist devices

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Abstract

Background Cardiac left ventricular assist device (LVAD) placement is a common therapy for heart failure. Non-cardiac surgical care of these patients can be complex given the need for anticoagulation, perioperative monitoring, comorbidities, and anatomical considerations due to the device itself. There are no guidelines or significant patient series reported to date for laparoscopic procedures in this population. We herein report the techniques and outcomes for commonly performed laparoscopic procedures in patients with LVADs at a high volume center.

Methods From our database of patients with ventricular assist devices, we retrospectively identified patients who underwent laparoscopic abdominal surgery. Intraoperative and perioperative data were collected, including anticoagulation management, transfusions and complications. Techniques and preoperative considerations from the surgeons were also compiled and described.

Results Of 374 patients that had placement of LVADs, 17 had an elective laparoscopic procedure: enteral access placement ($n=7$), cholecystectomy ($n=6$), hernia repair ($n=2$), small bowel resection ($n=1$) and splenectomy ($n=1$). Preoperative evaluation routinely included radiologic imaging to evaluate driveline location. The most common abdominal entry technique was a periumbilical open Hasson technique (11/17). No cases were converted to open. Overall, the average blood loss was 132 ± 64 mL and the average operative time was 1.8 ± 0.3 h. Five of the 17 patients required intraoperative blood transfusion. No patients suffered perioperative thrombotic events or LVAD complications secondary to holding anticoagulation. No patients required interventions or reoperation for bleeding complications. There were no mortalities related to these procedures.

Conclusions Laparoscopic abdominal procedures are safe and feasible in patients with LVADs. Although special consideration for bleeding and thrombotic risks, placement of ports and perioperative management is required, the presence of a LVAD itself should not be considered a contraindication for laparoscopic surgery and may in fact be the preferred method for access in these patients.

Keywords LVAD · VAD · Ventricular assist device · Anticoagulation · Driveline

The implantation of durable cardiac left ventricular assist device (LVAD) for heart failure as opposed to medical therapy has demonstrated clinically significant survival benefit and improved quality of life [1]. More than 25,000 left ventricular assist devices have been implanted worldwide with increasing 2-year survival rates of greater than 70%. And although initially intended as a bridge to transplant, up to 46% of devices are now used as destination therapy for heart failure [2]. Thus, as the prevalence of LVAD patients continues to rise, so does the likelihood that these patient may need elective or semi-elective abdominal operations.

When confronted with a surgical consultation for non-cardiac surgery for heart failure patients with a LVAD, there may be a bias to recommend non-operative or open treatment. Non-cardiac surgical care of these patients can be complex, given the anticoagulation requirements for the device, perioperative monitoring, associated comorbidities and anatomical considerations due to the device itself. And although complex, the presence of a LVAD does not need

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to be a contraindication for non-cardiac surgery. Several small series and case reports have demonstrated the safety of different types of non-cardiac surgery in LVAD patients [3–8]. However, no significant patient series or guidelines exist to date for laparoscopic surgery in this patient population. Given our high volume center for LVAD placement, we describe the techniques and outcomes of laparoscopic procedures in the LVAD patient population.

Methods

A retrospective chart review was conducted of all patients at our institution who had undergone general surgery procedures after having received a LVAD between 2008 and 2016 and was approved by the University of Chicago's Institutional Review Board. These patients were identified from our prospectively maintained database of patients with LVAD placement ($n=374$). Of the 33 patients that had a general surgery procedure, open and emergent general surgery cases were excluded, leaving 17 patients who underwent elective laparoscopic procedures. Chart review of these patients included anticoagulation regimen. In particular, we noted the date warfarin was held, the usage of heparin drip in the immediate postoperative period, and the day warfarin was restarted. In review of laboratory values, the preoperative and postoperative international normalized ratio (INR), hemoglobin, platelet count, and partial thromboplastin time (PTT) were recorded. We captured the preoperative and intraoperative anesthesia notes, any preoperative and intraoperative transfusions, along with estimated blood loss, length of surgery from the first incision to closure, and the LVAD pump flow and index settings during the intraoperative period. Postoperative complications were determined during the initial hospitalization, on follow up clinic visits and during readmissions. Any postoperative transfusions occurring within the same admission were noted. Technical considerations with relation to the LVAD were complied from operative reports and the surgeons.

Results

Of the 374 patients who had placement of ventricular assist devices, 17 underwent a laparoscopic procedure. The LVAD related demographics are described in Table 1. The majority of this cohort had an extra-peritoneal LVAD, the HeartMate II second-generation device (70.6%) and the majority of the cohort had LVAD placement as destination therapy (76.5%). The type of procedures and intraoperative data is described in Table 2. The laparoscopic procedures performed included enteral access placement ($n=7$), cholecystectomy ($n=6$), hernia repair ($n=2$), small bowel resection ($n=1$) and splenectomy ($n=1$). Preoperative evaluation routinely included

Table 1 Cardiac assist device demographics

Device type	
HeartMate II device (2nd generation) axial extra-pericardial	12 (70.6%)
HeartWare device (3rd Generation) centrifugal, hydrodynamic, intra-pericardial	5 (29.4%)
Indication	
Destination therapy	13 (76.5%)
Bridge to transplant	4 (23.5%)
Time with Implant (mean, range)	541 (28, 2206) days
Days off anticoagulation (median, range)	1 (1, 3) days

Table 2 Operative data

Procedure	Indication	Preoperative INR	Blood loss (mL)	Operative time (h)
Enteral access (7) Gastrostomy (6) Jejunostomy (1)	Failure to thrive (4) Dysphagia (2) Chronic aspiration (1)	1.6 ± 0.2	20 ± 22	1.0 ± 0.3
Cholecystectomy (6)	Cholelithiasis (4) Acute cholecystitis (1) Gallstone pancreatitis (1)	1.7 ± 0.2	130 ± 184	2.3 ± 1.1
Hernia repair (2)	Bilateral inguinal hernia (1) Incisional hernia (1)	1.9 ± 0.8	88 ± 18	2.8 ± 0.4
Small bowel resection (1)	Recurrent GI bleed (1)	1.3	50	1.8
Splenectomy (1)	ITP (1)	1.2	600	3.0
Overall	–	1.7 ± 0.1	132 ± 64	1.8 ± 0.3

radiologic imaging to evaluate driveline location with abdominal X-ray or CT (Fig. 1). Port placement was deliberate with relation to driveline. No extra ports were required in any cases due to positioning of the driveline. Various methods were used to enter the abdomen, but most common was a periumbilical open Hasson technique (11/17). No cases were converted to open. The average blood loss was 132 ± 64 mL and average operative time was 1.8 ± 0.3 h. Five of the 17 patients required intraoperative blood transfusion. Plasma was transfused for preoperative INR greater than or equal to 2.5 ($n = 2$). Packed red blood cells were transfused for preoperative hemoglobin less than or equal to 8 g/dL ($n = 1$) or blood loss greater than 500 mL ($n = 2$).

Anticoagulation outcomes

No patients had perioperative thrombotic events or LVAD complications secondary to holding anticoagulation. Anticoagulation was held on average 4.1 days before surgery and restarted on average 1.8 days after surgery. Average preoperative INR was 1.7 ± 0.1. In the immediate postoperative period, seven patients had anemia defined as a postoperative hemoglobin less than 8 g/dL, which resolved with blood transfusions. One patient had groin hematoma after inguinal hernia repair, which was managed non-operatively. Preoperative INR and platelet count did not appear predictive of postoperative bleeding. No patients required interventions or reoperation for bleeding complications. There was one hematoma after a bilateral inguinal hernia repair, which was managed conservatively. This hematoma was monitored with serial clinic visits and resolved after several months. There were no perioperative LVAD related thrombotic events.

Morbidity

There were no mortalities related to these procedures. There was one 30-day mortality which was not directly related to the laparoscopic intervention; this occurred in a patient who had a gastrostomy feeding tube placed as part of planned palliation. The patient required enteral access to be discharged to hospice. In this patient, percutaneous or endoscopic gastrostomy tube was not possible due to the location of the LVAD and driveline. There were no 60-day or 90-day mortalities in the remaining patients.

Discussion

In this report we demonstrate that laparoscopic procedures in patients with LVADs can be performed safely. The presence of a LVAD should not preclude the use of laparoscopy, however, special considerations should be taken. Part of these considerations includes understanding the anatomy of the LVAD device placement. Depending on the device model, the pump itself may be placed in a pocket that is extra-pericardial, (pre-peritoneally or intraabdominally) or intra-pericardial, such as the more recent small designs that sit within the pericardium itself. Understanding the different devices models allows for preoperative planning as to the expected location of the device and previous dissection planes. However, despite the location of the device pocket itself, all of these devices have an attached driveline that will still traverse the abdominal wall to an external power supply (Fig. 2). Thus every device, regardless of its extra-pericardial or intra-percardial position will require some anatomical preoperative planning.

At our institution, we routinely use preoperative imaging to trace the anatomy of the device and the driveline. This is done with the use of abdominal radiograph or computed tomography and helps to guide port placement for laparoscopy. Intraoperative techniques such as transillumination of the abdominal wall with the laparoscope can also help with placement of additional ports. When there is any questionable anatomy of the driveline, we recommend an open Hasson

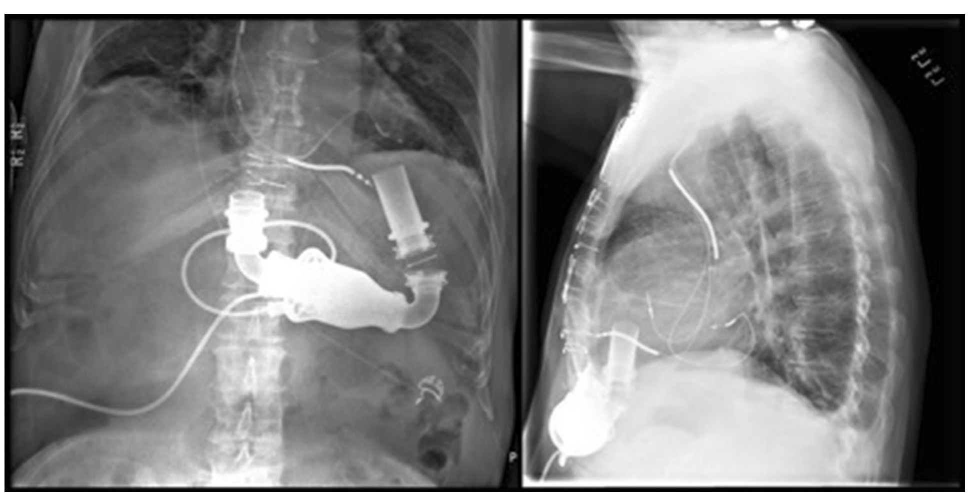

Fig. 1 Radiograph demonstrating the 2nd generation, HeartMate II device, placed in a preperitoneal pocket with driveline in relation to the abdominal cavity and abdominal wall

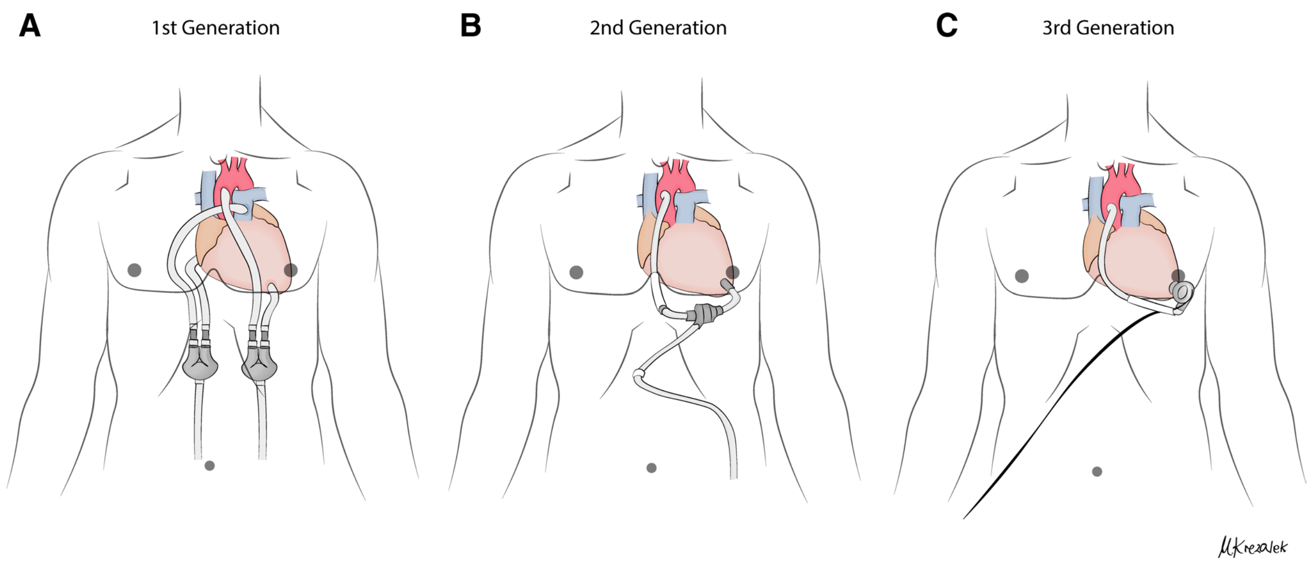

Fig. 2 Illustration of the usual or expected location of the device and driveline for each design. **A** First generation device depicted for historical purposes, placed in an intraperitoneal pocket unlike currently used cardiac ventricular devices. **B** Second generation device including the HeartMate II device, often placed in a preperitoneal pocket. **C** Third generation device, smaller design often placed intra-pericardial such as the HeartWare device

technique to gain entry as well as the use of intraoperative fluoroscopy to demarcate the course of the driveline. Additionally, port placement slightly lower on the abdominal wall than traditionally used will avoid instrumentation proximal to the driveline. Exposure or manipulation of the driveline or the LVAD itself should be avoided to minimize risk of device infection, as infection of the device can be a difficult problem to treat and is associated with a high morbidity and mortality rates [9, 10].

The second challenge in this patient population is management of perioperative anticoagulation. The use of anticoagulation is required due to the pro-thrombotic nature of cardiac ventricular devices and risk of thrombosis [11, 12]. However, this is conversely accompanied with a high rate of spontaneous bleeding, reported anywhere from 10 to 40% of patients with LVADs [13–18]. This rate of bleeding is higher than patients on anticoagulation for other indications [19]. This is attributed to the acquired von Willebrand syndrome [15, 20, 21] and platelet dysfunction [22] associated with the device itself, as well as the development of small bowel angiodysplasias in this patient population [13, 16]. Surgery only compounds this baseline risk of bleeding, and meticulous hemostasis is warranted.

Prior reports of elective non-cardiac surgeries in LVAD patients indicate the importance of tightly monitoring perioperative anticoagulation parameters [4, 5, 7]. However, it is unclear what anticoagulation goals should be preoperatively, as the target INR for maintenance of LVAD patients itself continues to be studied and adjusted weighing the risk of thrombosis against the risk of bleeding. We routinely hold warfarin preoperatively, 3–4 days before the procedure depending on surgeon preference, however, lovenox or intravenous heparin is used until the day of surgery. Anticoagulation should be restarted as soon as possible postoperatively given the risk of thrombosis with the LVAD. All patients have a type and screen as part of their preoperative requirement. In our series, about 40% of patients required a transfusion postoperatively, but no patients required reoperation for bleeding. We did not find a significant correlation between INR and the need for transfusion in our series. We found that procedures such as an inguinal hernia repair with a resultant dead space in the scrotum were high risk for hematoma formation. In our practice, if on postoperative day one there are no signs of bleeding on exam or laboratory studies, we restart anticoagulation within the first 24–48 h after the procedure. This is routinely done with an intravenous heparin bridge until therapeutic warfarin doses are achieved.

Given the complexity of LVAD patients, our institution strongly favors a multidisciplinary approach. In the perioperative period, the heart failure cardiology team manages the patients closely. Given the unique hemodynamics and device management, we also advocate for cardiac anesthesiologists to assist even with these laparoscopic procedures and cardiac nurses for post-operative care of these patients. Patients with LVADs require nursing staff familiarity with the devices, which may be more challenging in institutions where these devices are not inserted often. A team approach is critical to safely perform elective procedures on LVAD patients.

This study is limited by the small patient population, and was intended as a descriptive study. A multi-center or larger population study in the future can better describe the complication and morbidity rates. However, we demonstrate that laparoscopic procedures such as feeding access, cholecystectomy, hernia repairs and even splenectomy are safe in patients with ventricular assist devices. Although special consideration is necessary due to bleeding risks, thrombotic risks, placement of ports and perioperative management, the presence of a ventricular assist device itself should not be a contraindication for elective laparoscopic surgery. In fact, minimally invasive approaches may be the preferred technique for these patients who are already high risk for bleeding and other perioperative complications.

Compliance with ethical standards

Disclosures Dr. Jeevanandam is an advisor for Thoratec/Abbott. Dr. Uriel is an advisor for Thoraec/Abbott and HeartWare/Medtronic. Dr Yalini Vigneswaran, Dr Victoria Wang, Dr Monika Krezalek, Dr Vivek Prachand, Dr Stephen Wyers, Ms Colleen Juricek, and Dr Mustafa Hussain have no conflicts of interest or financial ties to disclose.

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