Anesthesiology Articles   Anesthesiology

2-1-2021

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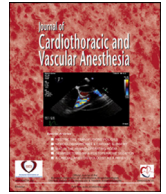
Recommended Citation

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Case Conference

Elective Total Knee Replacement in a Patient With a Left Ventricular Assist Device−Navigating the Challenges With Spinal Anesthesia

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ELECTIVE joint surgery in a patient with a left ventricular assist device (LVAD) may become increasingly common as these devices become entrenched in the management of patients with heart failure.[1,2] Furthermore, regional techniques may be reasonable anesthetic options in this challenging population.[3,4] This case conference discusses a spinal anesthetic for an elderly female with an LVAD who presented for an elective left total knee arthroplasty. The expert case commentaries that follow the case discussion further explore the anesthetic issues in light of the existing literature.

Case Report

A 72-year-old female presented for management of severe left knee arthritis, including consideration for a knee replacement. Her medical history was significant for coronary artery disease, ischemic cardiomyopathy, atrial fibrillation, hypertension, hyperlipidemia, insulin-dependent diabetes mellitus, and chronic kidney disease, with a baseline creatinine of 1.4 mg/dL. She had required percutaneous coronary intervention with deployment of drug-eluting stents in the left anterior descending and right coronary arteries three years ago. She had recovered from breast cancer that was managed with left mastectomy, chemotherapy, and radiation more than 10 years previously. She also had undergone a right knee replacement within the last 2 two years.

Her significant systolic heart failure had resulted in placement of an LVAD (HeartMate 3; Abbott Laboratories, Abbott Park, IL) 16 months previously. The implantation of the LVAD was complicated by right-sided heart failure requiring inotropic support and titration of sildenafil. Thereafter, she developed a driveline infection that responded to aggressive antibiotic therapy. She had recovered from a subdural hematoma after a fall within the last year. Her current medication schedule included aspirin, hydralazine, irbesartan, sildenafil, and warfarin.

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Physical examination revealed a normotensive elderly female with a well-functioning LVAD. A recent transthoracic echocardiogram revealed a left ventricle with an ejection fraction of 55% and with adequate drainage by the LVAD, intermittent opening of the aortic valve with no aortic regurgitation, and a mildly dilated right ventricle with mild systolic dysfunction. There was mild tricuspid regurgitation, and the estimated pulmonary artery systolic pressure was in the normal range. The electrocardiogram revealed rate-controlled atrial fibrillation with no evidence of myocardial ischemia. The chest radiograph revealed normal lung fields, sternal wires, and an LVAD.

After comprehensive assessment and discussion, the patient agreed to left total knee replacement. She stopped her warfarin six days before surgery and was admitted two days before surgery for maintenance of adequate anticoagulation with titrated systemic heparin therapy. The heparin infusion was discontinued four-six hours before surgery. The international normalized ratio and the partial thromboplastin time were within the normal range the morning of surgery. In the preoperative waiting area, the patient received an intravenous line and anxiolysis with titrated midazolam, followed by placement of a left adductor canal catheter for postoperative analgesia.

Upon arrival to the operating room, nasal cannula oxygen therapy was continued. Standard noninvasive monitors were placed as recommended by the American Society of Anesthesiologists. A nurse coordinator from the LVAD service was present throughout the perioperative period. A left radial arterial line was placed, and volume expansion was initiated with a slow bolus of crystalloid (500 mL total). The patient received a lumbar spinal anesthetic at the L3-to-L4 level, with a total of 12 mg of hyperbaric bupivacaine without complication. The sensory level for the spinal anesthetic was confirmed at T10.

The patient requested light sedation that was provided with titrated infusion of propofol. The vasoactive therapy included infusions of epinephrine for support of right ventricular systolic function and phenylephrine for support of systemic vascular resistance. The left knee replacement proceeded smoothly with minimal blood loss, and the patient tolerated the procedure very well.

At the conclusion of the procedure, the patient was admitted to the cardiac surgical intensive care unit on no vasopressor support. The patient's postoperative course was uncomplicated. She was discharged from the intensive care unit within 48 hours and thereafter to home on postoperative day five. Her anticoagulation was reinitiated by the second postoperative day after removal of the adductor canal catheter. At a hospital visit one month after surgery, the patient had recovered well with ongoing excellent function of her LVAD.

Discussion

Noncardiac surgery in patients with LVADs is becoming more frequent, and with proper preparation, has a reported low incidence of morbidity and mortality.[1-4] Both elective and emergency procedures may proceed safely with careful consideration for optimizing function of an LVAD in the perioperative period.[4-7] Although uncommon, total hip and knee replacements in patients with LVADs have been reported.[8-10]

Recent data suggest that the number of LVADs implanted every year continues to increase.[5-7] The implantation of an LVAD is typically a therapeutic bridge to discrete outcomes as follows: bridge to decision (further evaluation to determine heart transplantation candidacy), bridge to transplantation (LVAD is a temporizing measure until heart transplantation), bridge to recovery (LVAD is removed after myocardial recovery), or bridge to destination (LVAD is the final therapy).[11-16] The increasing prevalence of patients with LVADs means that noncardiac procedures will increase gradually in this setting, prompting a major focus on the perioperative approaches to this challenging population in order to minimize perioperative morbidity and mortality.[4-10]

In this patient, the indication for LVAD implantation was heart failure with reduced ejection fraction as a result of severe ischemic cardiomyopathy.[1-5] Based on a review of serial transthoracic echocardiograms thereafter, the patient's left ventricular ejection fraction gradually improved to 50% to 55%, as documented in the case presentation.[17] The left ventricular unloading by an LVAD often has facilitated recovery of ejection fraction >55% in more than 30% of recipients within six months.[17] In an additional 15% to 20% of recipients, the left ventricle will recover to an ejection fraction >40%.[17] In selected patients, the bridge to recovery route will be completed, prompting removal of the LVAD thereafter.[15-17]

As outlined in the case description, the presented patient had right-sided heart systolic dysfunction after LVAD implantation, a common perioperative consideration with an incidence of at least 20% to 40%, depending on the definition.[18,19] Right-sided heart failure in this setting occurs for multiple reasons in the perioperative period.[18,19] With appropriate medical and mechanical perioperative management, there typically is gradual improvement of right ventricular systolic function to allow for a steady clinical recovery.[19,20] In the present patient, the recovery of right ventricular function was significant but not complete, given that the patient was at home but with mild systolic dysfunction before her left knee replacement.

This patient had a third-generation contemporary LVAD, with lower rates of pump thrombosis and disabling stroke compared with previous devices.[20,21] The risks of surgical bleeding in anticoagulated patients undergoing joint arthroplasties must be weighed against the risks of LVAD pump complications when deciding about interruptions in anticoagulation.[22,23] The greatest risk for thrombotic complications is notably during the first six months after LVAD implantation.[24] The preparation for this complex case included a multidisciplinary team approach to plan the procedure with input from all stakeholders, including orthopedic surgery, cardiology, and anesthesiology. Perioperative anticoagulation was discussed at length to balance the risks of bleeding with neuraxial anesthesia with the risks of thrombosis in the LVAD, resulting in the anticoagulation-free window at the time of surgery. The heparin infusion was stopped four-six hours before surgery, and the patient's candidacy for neuraxial anesthesia was confirmed

with a normal coagulation profile. The anesthesia team carefully discussed the risks and benefits of a peripheral nerve block with either a primary spinal or general anesthetic, both of which were appropriate choices. The primary anesthetic technique for lower extremity joint replacement does not conclusively appear to influence clinical outcomes.[25,26] A recent systematic review suggested that spinal anesthesia may decrease hospital length of stay but has similar rates of mortality and thrombotic complications compared with general anesthesia.[25] On the other hand, a population-based study suggested that spinal anesthesia may significantly reduce mortality at 30 days, morbidity, hospital stay, and mortality after total knee replacement.[26] After careful discussion of the alternatives with the patient, she elected for a primary spinal anesthetic with postoperative multimodal analgesia, including a continuous saphenous nerve block via an adductor canal catheter.

An important anesthetic consideration with the spinal anesthetic was acute peripheral vasodilation and a subsequent decrease in preload. This sequence could acutely decrease left ventricular end-diastolic volume to cause inflow cannula obstruction as a result of a "suck-down" event and precipitate hemodynamic instability.[1-3] To address this concern, the anesthetic plan was crafted in the following fashion: intense blood pressure monitoring with a radial arterial line, augmentation of preload with judicious volume expansion, support of right ventricular systolic function with low-dose epinephrine infusion, and preservation of systemic vascular resistance with titrated phenylephrine infusion. Hyperbaric bupivacaine was selected to facilitate predictable spread and duration of the spinal anesthetic. Alternative neuraxial techniques, such as a spinal catheter or epidural catheter, potentially could be safer in terms of slower titration of the neuraxial anesthetic for a more gradual onset of the sympathectomy. To facilitate a smooth but gentle hemodynamic onset of the sympathectomy, the spinal anesthetic was dosed for a T10 dermatomal level of blockade, which typically has a less intense sympathetic blockade than blocks at higher spinal levels. Furthermore, the intensity of the sympathectomy was managed with the strategies of beat-to-beat monitoring of systemic blood pressure, volume expansion, and titrated vasoactive therapy, as previously outlined.

The surgical team also used a tourniquet to minimize blood loss.[27,28] The release of the tourniquet induces a period of ischemia/reperfusion in which acid and metabolic byproducts generated during anaerobic metabolism then are released systemically.[28,29] These metabolic products may acutely lower systemic pH and lead to a short but sudden onset of systemic vasodilation with decrements in preload, an increase in pulmonary vascular resistance, and decreased inotropy that must be managed carefully in the setting of underlying right-sided heart dysfunction, as outlined in this case conference.[28,29] The close monitoring of systemic blood pressure in the presented patient facilitated titration of the vasoactive support to support right ventricular function and systemic vascular resistance for smooth navigation of the left lower extremity reperfusion after tourniquet release.

An additional high-risk component of knee replacement for this challenging patient was the bone cement implantation syndrome that can provoke hemodynamic instability and cardiac arrest.[30,31] This syndrome occurs with significant systemic embolism of orthopedic bone cement to cause decreases in systemic vascular resistance and preload with concomitant pulmonary hypertension and myocardial depression.[30,31] This sequence of events clearly would result in significant hemodynamic instability in the presented patient, given her baseline pulmonary hypertension and compromised right ventricular function.[30,31] Cementless implantation techniques are available and represent an option in patients who are at a high risk for complications in the setting of bone cement implantation syndrome.[30,31] Although this possibility was discussed in detail with the surgical team, the poor bone quality encountered during the procedure prompted an implantation technique that included cement. The vigilance and preparation of the intraoperative team in the presented patient facilitated medical support of ventricular function and systemic vascular resistance in the event of significant bone cement embolization.

The patient tolerated the procedure without major perioperative complications. Elective surgery increasingly is common in patients with LVADs. With careful planning, elective surgery can be performed safely in these patients. This case conference highlighted that a spinal anesthetic can be performed safely in this challenging setting if the patient is a candidate for neuraxial analgesia and careful attention is given to managing the hemodynamic effects of the anesthetic and the surgical procedure.

Expert Commentary†
†N. Patel
†J. Sanders

According to the American Heart Association, nearly seven million adults live with heart failure across the United States.[32] The US Food and Drug Administration has approved the use of LVADs since 1994.[16] Since then, their clinical application has become more widespread and prevalent for the management of end-stage heart failure.[1-3] Initially, LVADs were strongly indicated as a bridge to transplantation and bridge to recovery in patients whose cases were refractory to pharmaceutical treatment.[11-15] However, additional trial data not only showed a significant increase in life expectancy compared with optimal medical management, but also improvements in quality-of-life metrics.[32] In addition, an ever-increasing number of patients are having LVADs placed as destination therapy.[16] A previous trial showed that about 25% of these patients will return at a later time for noncardiac surgery.[33] Therefore, it is imperative that the anesthesiologist be familiar with the perioperative management of LVAD patients presenting for noncardiac elective surgery.[33,34] In this case conference, the perioperative management for a complex patient with an LVAD who underwent left total knee replacement under spinal anesthesia was presented.

A literature search revealed that the case presented was likely one of the first documented reports of a patient with an LVAD undergoing total knee replacement under spinal

anesthesia. Although this type of joint arthroplasty commonly is performed with neuraxial anesthesia, this anesthetic approach has been limited in patients with significant cardiovascular compromise.[35] A feared complication of neuraxial anesthesia is the acute sympathectomy that may provoke hemodynamic instability in LVAD patients.[36] Because these patients are dependent on adequate venous return, decreases in preload from systemic venodilation can decrease left ventricular diastolic volume significantly, with consequent risk for "suck-down" events with inflow cannula obstruction, pulmonary hypertension, and right ventricular failure.[36,37] The support of right ventricular systolic function in this perioperative setting often has resulted in the selection of inotropic therapy and inhaled pulmonary vasodilators, such as nitric oxide or epoprostenol, to both boost inotropy and unload the right ventricle.[5-7] In the presented case, the patient had mild right ventricular systolic dysfunction and pulmonary hypertension requiring sildenafil maintenance therapy before the scheduled orthopedic surgery.

In this case, the patient was hydrated with a crystalloid challenge to ensure adequate right ventricular end-diastolic volume. An epinephrine infusion was added to support right ventricular systolic function. In anticipation of decreased systemic vascular resistance from the sympathectomy, the anesthesia team also started and titrated a phenylephrine infusion. The titration of intravenous volume expansion must be monitored closely to avoid precipitating right ventricular failure. Volume overload also may cause supraventricular arrhythmias such as atrial fibrillation, atrial flutter, and multifocal atrial tachycardia from right atrial stretch that may further complicate right ventricular failure and cardiogenic shock. The acute management in this setting also may require prompt electrical cardioversion.

Patients who require LVADs are also on chronic anticoagulation to minimize the risk of thrombosis, thromboembolic stroke, and peripheral thromboembolism.[38] Patients are often on oral anticoagulation with vitamin K antagonists and/or antiplatelet medications, such as aspirin.[38] Because of these coagulopathy issues, general anesthesia often is favored to avoid the risks of neuraxial hematoma.[38,39] In the case presented, the patient had a third-generation LVAD (HeartMate 3), which has a lower thrombotic risk compared with earlier devices as a result of factors such as smaller size, continuous flow, and inner textured surface of the cannulae.[3-7] In elective procedures, these patients are bridged from warfarin to intravenous heparin, with the heparin stopped four-six hours before the surgery, such as in the case presented.[38] In more emergency situations, warfarin reversal can be achieved with interventions such as administration of fresh frozen plasma and/or prothrombin complex concentrate.[38] Increased bleeding risk in the setting of an LVAD also may be a result of acquired von Willebrand syndrome caused by high shear forces. Viscoelastic testing can provide guidance of correctional therapies including platelet transfusion.[38]

Subarachnoid and epidural blocks are common anesthetic techniques in knee procedures.[25,40,41] A recent systematic review comparing the effectiveness of spinal anesthesia with

femoral sciatic block for knee arthroscopy demonstrated that peripheral nerve blockade facilitated a longer duration of postoperative analgesia, less analgesic rescue, and a better patient safety profile.[41] In the presented patient, a saphenous nerve block was included for perioperative analgesia via a catheter in the adductor canal for local anesthetic delivery. This technique as part of a multimodal approach achieved effective postoperative analgesia. Additional systematic literature review revealed that for total knee arthroplasty, neuraxial anesthetic techniques compared with general anesthesia shortened surgical times and hospital stay but otherwise were equivalent with respect to mortality, infection, nausea, vomiting, and nerve palsies.[25]

A spinal technique is relatively novel in the setting of an LVAD.[5] A retrospective case series of LVAD patients (n = 31) undergoing noncardiac procedures included a single patient having a cystoscopy under subarachnoid block.[5] For that case, the patient's anticoagulation was managed carefully perioperatively, as was the patient in this case.[5] There were no complications reported. These cases suggest that in selected patients, a spinal anesthetic is reasonable in the setting of an LVAD, with thoughtful management of perioperative hemodynamics and coagulation, as outlined in the case discussion and this expert commentary.

Peripheral nerve block techniques compared with parenteral and epidural analgesia for total knee arthroplasty typically decrease postoperative opioid consumption with superior analgesia, decreased hospital stay, and faster recovery of muscle strength.[42,43] However, the few reported cases of orthopedic surgeries in patients with LVADs described the thoughtful application of peripheral nerve blocks for both upper and lower extremity procedures.[35,44] In the presented patient, a left adductor canal catheter was placed for both intraoperative and postoperative analgesia.

Bone cement implantation syndrome is a rare but well-known phenomenon, with a range of symptoms from transient hypoxemia to complete cardiovascular collapse.[30,31] The pathophysiology is likely a result of high intramedullary pressure between the cement and prosthesis that allows the cement to extravasate into the medullary cavity of the bone.[45,46] Subsequently, the medullary contents can embolize centrally to induce cardiopulmonary compromise.[30,31,45,46] Risk factors for this syndrome include older patients; established cardiopulmonary dysfunction; and bone disorders such as osteoporosis, osseous cancer, and fractures.[30,31,45,46]

A literature search revealed that there has been, to the authors' knowledge, no reported case of bone cement implantation syndrome in the setting of an LVAD. However, this syndrome remains an important perioperative concern because more patients with LVADs and compromised right ventricular function are undergoing major joint procedures such as total hip and knee arthroplasty.[2-7] The diagnosis of this important syndrome is suggested by features such as a sharp decline in end-tidal carbon dioxide, unexplained loss of consciousness, pulmonary hypertension, pulmonary edema, hypothermia, thrombocytopenia, arrhythmias, or cardiac arrest.[30,31] Perioperative management includes administering 100% oxygen and

hemodynamic rescue with titrated vasopressor and fluid therapy. As noted already, cementless implantation techniques should be encouraged. If this approach is not possible, appropriate anesthetic monitoring standards and guidelines should be followed in the event that bone cement implantation syndrome occurs.[30,31]

The literature supporting the role of spinal anesthesia for noncardiac procedures in patients with LVADs still is limited. This anesthetic approach is a reasonable choice in selected patients and requires thorough perioperative multidisciplinary planning and management. This perioperative planning can address challenges such as anticoagulation status, hemodynamic stability, and multimodal analgesia. Despite the challenges, the brilliant management of this presented patient demonstrated that a spinal anesthetic can be conducted safely for a patient with an LVAD in the setting of a multidisciplinary team.

Expert Commentary‡

‡R.J. Fernando
‡B.N. Morris

An LVAD is an established treatment to provide mechanical support for patients with severe heart failure.[47] Although LVADs initially were designed as temporary devices, they are now a viable long-term option.[47] As these devices disseminate through clinical practice, the likelihood also will increase that patients with LVADs will present for noncardiac surgery, as in this presented patient.[1-3] It therefore is imperative that anesthesiologists be familiar with their anesthetic implications.[1-7]

In this case conference, the authors reported the use of a spinal anesthetic for a patient with an LVAD presenting for elective knee surgery. The selection of neuraxial anesthesia for patients with LVADs rarely is seen in the literature, although it previously has been reported.[5,48] In 2012, Bhat et al. reported their institutional experience with 36 patients.[48] Because some of these patients presented multiple times, there were 63 total noncardiac surgical procedures. A spinal anesthetic was used once for a urology procedure. The majority of the remaining procedures were performed with the patient under general anesthesia (88.8%) and the remainder requiring monitored anesthesia care.[48]

The rarity of neuraxial anesthesia in patients with LVADs is further supported by other single institutional reports.[3-5] In 2016, Degnan et al. reported their experience with 31 patients and 74 noncardiac surgical procedures.[5] General anesthesia was used for 13 events (18%), monitored anesthesia care was used in 60 events (81%), and regional anesthesia was used in one event (1%). Specifically, "regional anesthesia" referred to a spinal anesthetic placed in a patient with hematuria undergoing cystoscopy. Anticoagulation for this patient was withheld because of bleeding, and normal laboratory values for coagulation were confirmed before arachnoid puncture. A heparin drip was initiated postoperatively, although the exact timing was not reported. Regardless, there were no reported complications related to the anesthetic. In 2017, Mathis et al. retrospectively reviewed 702 cases from 246 patients over a nine-year period.[49] In total, 177 (25%) of these procedures were completed with the patient under general anesthesia, and 525 (75%) used monitored anesthesia care. Even though regional anesthesia was used in six patients (0.9%), none of these was a neuraxial technique.[49]

The presence of an LVAD does not inherently contraindicate use of a spinal anesthetic and therefore raises the question of why it is used so infrequently. Almost certainly, the biggest reason relates to the anticoagulation associated with LVADs.[50] The goal international normalized ratio for patients with durable continuous-flow LVADs is typically 2.0 to 3.0.[24] Whether anticoagulation is continued into the perioperative period is procedure-dependent. The 2013 guidelines from the International Society for Heart and Lung Transplantation suggested continuing warfarin when procedures have insignificant bleeding risk.[51] Continuity of anticoagulation certainly would prohibit neuraxial anesthesia, given the recommendation from the American Society of Regional Anesthesia that the coagulation status be normalized before placing a neuraxial block.[52]

If warfarin is stopped preoperatively, however, neuraxial anesthesia could be considered.[52] There is a possibility, however, that patients taking warfarin long term may achieve a normal international normalized ratio in the first few days after cessation despite lack of adequate factor repletion.[52] An interruption of warfarin therapy for five days before the procedure, in addition to normalization of the clotting status, has been recommended.[52] In this patient, the care team was compliant with this guideline because they stopped warfarin six days before the procedure per institutional protocol, and a normal coagulation profile was demonstrated.[52,53]

The postoperative plan for anticoagulation also is relevant when considering neuraxial anesthesia, especially when an epidural catheter is used.[52,53] In addition to risk of bleeding during epidural catheter insertion, the removal of the catheter is also a critical time.[52,53] The timing of catheter removal therefore must be considered carefully and discussed because it potentially could result in delaying resumption or require interruption of anticoagulation. However, this is primarily an issue when the epidural catheter is maintained into the postoperative period. In the case of the presented patient who underwent total knee arthroplasty, one option would be to place an epidural and remove it at the end of the procedure. The benefit of this technique over spinal anesthesia is that it allows for slower titration of the local anesthetic, which may aid in hemodynamic stability.[54] The potential disadvantage is that this still could result in a delay in resuming anticoagulation because the spinal placement would occur before surgery compared with removal of the epidural catheter after completion of surgery. However, this may not even be a relevant issue because anticoagulation may not be possible in the immediate postoperative period depending on the surgical risk of bleeding.

Another potential risk for bleeding that may be less appreciated is the acquired von Willebrand syndrome that may be present in patients with an LVAD.[55,56] High-molecular-weight von Willebrand factor is the functional form of the multimer that plays a role in hemostasis and thrombosis. Shear stress from LVAD flow ultimately leads to mechanical disruption of these high-molecular-weight multimers, causing functional changes and impaired physiologic function.[55,56] Prospective

sampling has demonstrated decreases in the ratio of high-to-low weight multimers, as well as an overall decrease in von Willebrand factor−related laboratory markers, although still within the normal range.[55,56] However, these levels may not be able to account for structural changes that predispose to bleeding risk.[56] Overall, additional investigation would be helpful to understand the clinical significance of the acquired von Willebrand syndrome as it relates to neuraxial anesthesia.

The high degree of shear stress from the LVAD also induces changes that ultimately impede platelets from working effectively.[57,58] This pathology can be evident soon after a patient receives an LVAD. An additional complicating consideration in the clinical picture is that both quantitative and qualitative platelet defects may be present.[57,58] Despite this, not all patients with LVADs experience bleeding complications. Given that these derangements may affect some patients more than others, it may be prudent to interpret the lack of adverse events based on a few case reports of successful neuraxial anesthesia with caution. Ultimately, given these confounders, additional research is necessary to characterize the safety and suitability of neuraxial anesthesia in this patient population.[55-58]

The types of surgeries patients with LVADs undergo may be another factor to explain the low use of neuraxial anesthesia. Even though the risk associated with elective noncardiac surgery may be acceptable in this population, it remains high at times and may explain an increased threshold for noncardiac surgery.[2-6] In reviewing the recent literature, it appears that the more common procedures are gastrointestinal endoscopy and implantation of cardiac electronic devices.[2-6] Even though these procedures may be elective, they likely were considered important, given the associated risks of gastrointestinal bleeding and poorly tolerated arrhythmias in this challenging population.[2-16] Clinicians therefore may be more inclined to refer patients for these procedures over others such as total knee arthroplasty, which may seem more elective, because these more urgent problems could cause significant morbidity and mortality.[2-6]

In this case, the type of surgery was conducive to neuraxial anesthesia, and the patient chose a spinal anesthetic. The risks and benefits of primary knee arthroplasty have been reviewed comprehensively with respect to anesthetic technique, although it is likely that very few patients in this large sample had LVADs.[59] This patient population has a unique risk profile that is highly specific and therefore it may not be reasonable to assume that neuraxial anesthesia would confer benefit in this challenging subgroup, based on extrapolating data from other large populations.

This consideration, however, does not negate the possibility that there may be clinical benefits with neuraxial anesthesia in these patients. The data showed that neuraxial compared with general anesthesia may improve outcomes for knee arthroplasty.[59] Assuming that neuraxial anesthesia is in fact the anesthetic of choice for lower extremity arthroplasty, the question becomes which specific neuraxial technique is the one of choice for a patient with an LVAD. In this presented patient, the anesthesia team chose a spinal technique supplemented by a peripheral nerve block. The level of block was chosen to balance adequate anesthesia with a limited sympathectomy in an effort to mitigate the extent of systemic vasodilation.

The possible role of central monitoring of hemodynamics also could have been considered in this case. In this case, the anesthetic plan did not include central venous pressure monitoring or placement of a pulmonary arterial catheter to follow the quantitative trends in cardiac output and systemic vascular resistance. In a patient such as this, central hemodynamic monitoring also could be accomplished noninvasively with focused transthoracic echocardiography either electively or for hemodynamic rescue.[60,61] This point-of-care imaging technique can facilitate diagnosis and management of hypotension as a result of variations in preload, right ventricular failure, and suction events. Furthermore, if unexpected hemodynamic compromise were encountered intraoperatively, point-of care echocardiography in expert hands can be used to organize clinical management rapidly.[59-61]

In summary, this case conference highlighted the successful use of neuraxial anesthesia in a patient with an LVAD for a noncardiac surgical procedure. Even though this was not the first case of such an occurrence, this anesthetic approach appears to be reported rarely in the literature. There are many possible explanations for this reporting incidence, including concerns relating to anticoagulation and the hematologic alterations associated with LVADs. Ultimately, additional investigation should evaluate the safety of neuraxial anesthesia in this patient population and determine how outcomes compare with general anesthesia.

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