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The Development and Implementation of Evidence-Based Preanesthesia Assessment Tools for LVAD Patients Undergoing Non-Cardiac Procedures

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The Development and Implementation of Evidence-Based Preanesthesia Assessment Tools for LVAD Patients Undergoing Non-Cardiac Procedures

Abstract

Abstract

A university-affiliated tertiary medical center with a newly developed Advanced Heart Failure and Mechanical Circulatory Support program identified the need to implement a more systematic approach to the preanesthesia assessment process for patients with a Left Ventricular Assist Device (LVAD) undergoing noncardiac procedures and standardized guidelines to determine the best blood pressure monitoring system for patients with an LVAD during these noncardiac procedures. A multidisciplinary panel of clinical experts developed an LVAD Preanesthesia Toolkit using standard recommendations identified via evidence-based literature and expert opinion. The Toolkit included an LVAD Preanesthesia Assessment (VaPA) tool and an LVAD Blood Pressure Monitoring Decision Tree. The Toolkit initiative utilized a checklist to promote safety and enhance access to LVAD-specific resource tools for anesthesia providers. An online education module outlining the details of the initiative was distributed to targeted users prior to a pilot implementation of the VaPA tool into clinical practice. Data collection concerning education dissemination revealed that 27.2% of anesthesia providers had reviewed and verbalized their understanding of the initiative. An analysis of the effectiveness of the VaPA tool was conducted in a 5-month retrospective review of electronic health records for LVAD patients undergoing noncardiac procedures. Outcome data revealed 100% accuracy in preanesthesia assessment documentation. Results indicated improved consistencies in documenting the LVAD specific components of the preanesthesia assessment.

Keywords

Left Ventricular Assist Device (LVAD), nurse anesthesia, preoperative assessment tool, preanesthesia assessment, noncardiac surgery

Cover Page Footnote

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Introduction

There are approximately 6.5 million adults living with heart failure in the United States (CDC, 2020). Heart disease is the leading cause of death in the United States, and heart failure is a contributing factor (CDC, 2020). Cardiac transplantation is the ultimate treatment for individuals diagnosed with terminal heart failure, or stage D heart failure as classified by the American Heart Association (Chung, 2018). A restricted number of available hearts for transplants results in significant wait times for a viable donor. An accessible treatment for these patients is a Left Ventricular Assist Device (LVAD), which can be used as a bridge to transplant and as long-term destination therapy (Chung, 2018). The first LVAD was implanted successfully in 1966, and their use has increased significantly with improved technology and pharmacology support in recent years (Chair et al., 2016). LVAD use has allowed patients with heart failure to return to a home setting and has led to improved survival rates.

A patient implanted with an LVAD continues to need other types of medical therapy in addition to cardiac support, and up to 49% of the LVAD patient population may require noncardiac procedures during their lifetime (Chung, 2018). For LVAD patients undergoing procedures that require anesthesia, the preanesthesia assessment should identify specific risk factors and medical issues that could affect anesthesia care for these patients. The two most significant complications in the LVAD patient population are bleeding and hemodynamic instability (Mathias et al., 2017). Despite these risks, patients with LVADs can have safe anesthesia care for noncardiac procedures. Anesthesia providers who are knowledgeable about LVAD physiology can safely care for patients with LVADs undergoing noncardiac procedures without subspecialized cardiac training (Chung, 2018; Degnan et al., 2016; Khoo, 2010; Peacher, 2016; Slininger et al., 2013). Specific fundamentals of perioperative anesthesia care and a thorough targeted preanesthesia assessment can minimize intraoperative complications and associated morbidity and mortality (AANA, 2016; ASA, 2012; Degnan et al., 2016).

Problem

High-acuity, low-frequency patient populations such as patients with LVADs present challenges for anesthesia providers. Infrequent exposure combined with a lack of educational opportunities can lead to unsafe practices and poor patient outcomes, especially with vulnerable patient populations (Turkelson & Keiser, 2017). Checklists are commonly used tools to prevent error during high-risk encounters or procedures, and their use to standardize clinical practice is common in medical care (Haugen et al., 2019). Checklist utilization is particularly advantageous during less common situations, as they direct provider attention to ensure inclusion of crucial steps that may otherwise be disregarded (Clark et al., 2012; Turkelson & Keiser, 2017).

Local Issue

A retrospective analysis of the electronic health record (EHR) identified two practice gaps. Review of baseline data of 10 noncardiac procedures performed in patients with LVADs demonstrated significant variability in the EHR documentation of recommended evidence-based preanesthesia assessment components. A second practice gap identified was the absence of an evidence-based systematic approach to choosing an appropriate method of blood pressure (BP) monitoring during the anesthesia care. This is a departure from national trends, where a stepwise approach to BP monitoring advances monitoring methods from noninvasive to invasive techniques as indicated (Degnan et al., 2016; Goudra & Preet, 2013). The rate of arterial line insertion for LVAD patients undergoing noncardiac procedures at this academic center also exceeded the national average.

Purpose

The purpose of the initiative is to standardize the elements of preanesthesia care for patients with LVADs presenting for noncardiac procedures through the development and implementation of an LVAD Preanesthesia Toolkit. The toolkit consists of two evidence-based resource tools, the LVAD Preanesthesia Assessment (VaPA) tool and LVAD BP Monitoring Decision Tree, to improve safety and reduce the potential risks associated with LVAD patients undergoing noncardiac procedures.

Background Literature

Medication History

Review of cardiac-specific medications, including anticoagulants (Level IIIA, IIIB, VA evidence), inotropes, diuretics, and antihypertensives (Level IIIB evidence), guide a safe perioperative experience (Chung, 2018; Degnan et al., 2016; ASA, 2012; Khoo, 2010; Peacher, 2016; Riha et al., 2010; Slininger et al., 2013; Stone et al., 2016. Patients with LVADs require chronic anticoagulation and antiplatelet therapy to reduce the risk of thrombosis and thromboembolic events (Peacher, 2016). Interruption in anticoagulation may increase the risk of thrombosis, which can lead to embolic stroke. Conversely, surgical hemorrhage is a significant risk (6.2%-90% incidence) in this patient population (Dalia et al., 2018; Davis et al., 2015; Mathias et al., 2017). Individualized perioperative anticoagulation regimens outlining set coagulation parameters should be determined through a collaboration between the surgical and heart failure teams, taking into consideration additional individual factors (e.g., type of surgery, elective vs emergent, and the patient's medical history) to decrease risk of intraoperative bleeding complications (Level IIIA, IIIB, VA evidence) (Chung, 2018; Degnan et al., 2016; ASA, 2012; Khoo, 2010; Peacher, 2016; Riha et al., 2010; Slininger et al., 2013; Stone et al., 2016).

Cardiovascular Health History and Review of Systems

Assessment of underlying hemodynamics guides the anesthesia provider in the correct intraoperative monitoring, including the need for invasive monitoring (e.g., arterial BP monitoring, central venous pressure monitoring, and pulmonary artery pressure monitoring) (Dalia et al., 2018) The review of recent cardiovascular diagnostic tests including echocardiogram imaging and a 12-lead electrocardiogram provides information about the functionality of the unsupported right heart and guides hemodynamic and fluid management (Level IIIA and VA evidence) (Chung, 2018; ASA, 2012; Dalia et al., 2018).

Cardiovascular implantable electronic devices (CIED) are common in patients with LVADs, and preoperative device preparation is a necessary component to ensure hemodynamic stability through rhythm regulation during anesthesia (Dalia et al., 2018; Firstenberg et al., 2011; Fleisher et al., 2014; Khoo, 2010; Peacher, 2016; Riha et al., 2010; Slininger et al., 2013). Multidisciplinary management concerning the type of procedure and potentiality of electromagnetic interference is recommended as part of the preanesthesia assessment (Level IIIA evidence) (Fleisher et al., 2014) Operative management of CIEDs in this patient population does not differ from any patient who has a CIED presenting for anesthesia, and attention to this element of the preanesthesia assessment should not be overlooked.

Ventricular Assist Device Preparation

The LVAD system is a crucial component for the anesthesia provider as it displays information that may be utilized to guide intraoperative management. Since no single parameter can provide indicative reasons for concern or pump failure, all pump parameters in addition to battery life and alarm history should be assessed during the preanesthesia assessment. Although cardiac subspecialty training is not necessary, the anesthesia provider should have detailed knowledge of LVAD physiology (Level IIIB and VA evidence) (Chung, 2018; Degnan et al., 2016; Khoo, 2010; Peacher, 2016; Slininger et al., 2013). The patient's heart failure team closely manages each patient's LVAD pump parameters and history.

Multidisciplinary care collaboration helps ensure proper preanesthesia preparation and attention to device management, as well as coordination of available LVAD-specific personnel for intraoperative device monitoring and to ensure the presence of necessary functional device equipment (Level IIIB, IVC, and VA evidence) (Chung, 2018; Dalia et al., 2018; Firstenberg et al., 2011; Khoo, 2010; Peacher, 2016; Slininger et al., 2013, Stone et al, 2016). Personnel varies by institution and includes registered nurses, advanced practice providers in cardiology or electrophysiology, cardiac surgeons and/or cardiopulmonary perfusionists.

The LVAD system controller conveys vital data of specific parameters concerning device functionality (e.g., pump speed, power and flows, and pulsatility) (Dalia et al., 2018). Predetermined by the implanting physician, pump speed is fixed and programmed to provide optimal left ventricular (LV) unloading while allowing for intermittent LV ejection (Dalia et al., 2018). The power parameter indicates the energy it takes to run the LVAD pump. A gradual or baseline elevated power may indicate an increase in LV preload or a high pump speed setting, while a reduction in power may indicate a low pump speed setting or a reduced LV preload (Chung, 2018; Dalia et al., 2018).

The amount of blood supplied to systemic circulation from the LVAD is measured by pump flow. LVAD flows are linear to pump speed and power but can be influenced by LV contractility and pressure differences across the pump; therefore, high blood pressure and/or low LV preload will decrease pump flow (Chung, 2018; Dalia et al., 2018). An abrupt increase in pump power without change in pump speed or flow needs immediate attention as this phenomenon can indicate pump thrombosis or failure (Chung, 2018; Dalia et al., 2018). Pulsatility is measured slightly differently depending on the LVAD device type. In general, a higher pulsatility measurement translates as adequate LV preload and/or an improvement in intrinsic LV contractility and vice versa (Dalia et al., 2018).

Infection Prevention

Infection is a leading cause of death for patients with destination therapy LVADs (Dunlay et al., 2016). An LVAD increases the risk of a patient's susceptibility to microorganism transmission due to the direct route from the external LVAD controller to the internal pump. LVAD-specific infection prevention and antibiotic management should be discussed with the multidisciplinary care team ahead of surgical procedures (Level IIIB, IVC, and VA evidence) (Dalia et al., 2018; Firstenberg et al, 2011; Khoo, 2010; Riha et al., 2010; Slininger et al., 2013, Stone et al., 2016). While standard, it is necessary to maintain aseptic technique for all invasive procedures due to a higher vulnerability to infection.

Blood Products

Preoperative preparation of blood product availability should be considered (Level IIIB evidence) (Degnan et al., 2016). Packed red blood cells, administered in 4.3%-41% of LVAD patients undergoing noncardiac procedures, are the most commonly administered blood product (Degnan et al., 2016; Stone et al., 2016; Mathias et al., 2017). Bleeding is a particular concern for patients where the LVAD therapeutic strategy is a bridge to transplant, since minimizing the use of blood product transfusion is attempted in order to decrease alloimmunization (Chung, 2018). Multidisciplinary preanesthesia planning for blood product administration can establish best practices based on the patient's individual goals of care.

Blood Pressure Monitoring in LVAD Patients

Since hemodynamics are often unstable in LVAD patients, the choice of BP monitoring technique is an important element in the preanesthesia process. Almost 75% of patients with an LVAD undergoing a noncardiac procedure require pharmacological support intraoperatively to maintain the recommended mean arterial BP of at least 70 mm Hg (Chung, 2018; Dalia et al., 2018). The use of the LVAD BP Decision Tree will help guide providers in an evidence-based choice of BP monitoring.

With a success rate of at least 95%, the gold standard for BP monitoring in LVAD patients is the use of a manual sphygmomanometer with a doppler and should be considered first for intraoperative BP monitoring (Level IIA, IIB, and IIIB evidence) (Bennett et al., 2010; Lanier et al., 2013; Pour-Ghaz et al., 2019; Stone et al., 2016). Alternatively, the standard automated non-invasive BP (NIBP), when obtainable, is reliable and accurate when compared with invasive BP monitoring and can be considered when the NIBP doppler method is not feasible (Level IIIB evidence) (Barbara et al., 2017, Degnan et al., 2016; Goudra & Preet, 2013; Lanier et al., 2013). However, nonpulsatile flow is a common feature of a patient with an LVAD and negates the effectiveness of many conventional methods of BP monitoring. Noninvasive methods rely largely on sensing the pressure generated by blood pulsing off the vessel walls to determine a numeric pressure reading (Lanier et al., 2013). Additionally, hemodynamic changes that occur with induction of anesthesia may reduce the effectiveness of NIBP for the anesthetized LVAD patient (Barbara et al., 2017). Therefore, additional BP modalities need to be considered and available should NIBP attempts become unsuccessful (Level IIB and IVB) (Barbara et al., 2017; Lanier et al., 2013).

If standard automated NIBP is not successful preoperatively and conducting a doppler NIBP is not feasible during the procedure, an arterial line can be placed, with a low threshold for using ultrasound technology (Level IA and VB evidence) (Chung, 2018; Yeap at al., 2019). Arterial pressure monitoring is not ideal and should only be used when NIBP fails as an option. BP monitoring gaps up to 20 minutes are reported across studies in which an arterial line was placed in LVAD patients after induction of anesthesia. Gaps in BP monitoring do not comply with national standards set by the American Association of Nurse Anesthesiology (AANA), which states BP must be assessed every 5 minutes during the administration of anesthesia (AANA, 2019; Barbara et al., 2017; Mathias et al., 2017). Arterial line placement in LVAD patients can be challenging for the anesthesia provider, especially in the LVAD patient who has low pulsatility, making it more difficult to palpate a pulse, and in LVAD patients who have scarring from previous arterial line placement attempts (Chung, 2018). Ultrasound use for the placement of an arterial line has a higher success rate with fewer attempts than the conventional palpation technique (Yeap, 2019).

Methods

This quality improvement (QI) initiative was conducted as part of a Doctor of Nursing Practice Nurse Anesthesia scholarly project at a university-affiliated tertiary medical center with a newly developed Advanced Heart Failure and Mechanical Circulatory Support program. A multidisciplinary approach was taken to create evidence-based resources for anesthesia providers evaluating patients with LVADs presenting for noncardiac procedures. Online educational strategies were engaged to disseminate knowledge of the LVAD Preanesthesia Toolkit. Evaluation of both the uptake of the educational modules and the impact on clinical practice were used to evaluate the QI initiative.

Ethical Considerations

The Institutional Review Board (IRB) of the academic center reviewed the initiative and determined it to be a QI project not requiring IRB oversight. All elements of the project adhered to human subjects' protections in accordance with the Collaborative Institutional Training Initiative standards. All data were de-identified and stored in protected areas.

LVAD Preanesthesia Toolkit Development

The multidisciplinary team of clinical experts that developed the VaPA tool and the LVAD BP Monitoring Decision Tree comprised two cardiac physician anesthesiologists, two cardiac surgeons, two LVAD coordinators (a family nurse practitioner and a certified physician assistant), and two Student Registered Nurse Anesthetists (SRNAs). The team was unable to identify in the literature already developed checklists pertaining to the preanesthesia assessment for LVAD patients undergoing noncardiac surgery. The VaPA and BP monitoring guidelines were informed by the literature as well as expert opinion and were vetted by experts.

The Toolkit development phase extended over a 5-month period with monthly review meetings. Through an iterative process, the expert panel reviewed evidence-based standard recommendations, facility policies, and levels of evidence to focus and design the content of the LVAD Preanesthesia Toolkit, leading to the finalized and approved VaPA tool and LVAD BP Monitoring Decision Tree. The Appendix describes the evidence appraisal for the literature utilized in toolkit development. Levels of evidence were appraised using definitions outlined by John Hopkins Evidence-Based Practice Model (Dang et al., 2022). Tool content met inclusion criteria if the literature source had an appraisal rating of at least level III evidence and a B quality rating.

The LVAD Preanesthesia Assessment (VaPA) Tool

The goal of the assessment process using the VaPA tool is to ensure a systematic and consistent approach to the preoperative anesthesia assessment for every LVAD patient undergoing noncardiac procedures. **Figure 1** shows the evidence-based assessment components included in the VaPA tool and documented in the EHR.

Figure 1

Left Ventricular Assist Device Preanesthesia Assessment (VaPA) Tool

Medications History
- Anticoagulation medication
  - Last Dose taken
- Current medication review

Pertinent Laboratory Studies
- PT/INR, aPTT, Platelets
- Type and Screen (may not be necessary for all procedures)
- Hematocrit and Hemoglobin

Health History and Review of Systems: Cardiovascular
- **Presence of Cardiac Implantable Electronic Device (CIED)**
  - Verify type of device and whether patient is pacemaker dependent
  - Consult Electrophysiology
  - Consider device interrogation if > 6 months since previous interrogation
  - Have external defibrillator equipment and magnet
- **Pertinent Diagnostic Tests**
  - Echocardiogram
  - 12-lead electrocardiogram

Ventricular Assist Device Preparation
- Contact Heart Failure Team/necessary personnel
- Ensure presence of necessary device equipment: spare controller, extra batteries, base module)
- Considerations:
  - Type of Device
  - Therapeutic strategy: Bridge to transplant (BTT) or Destination Therapy (DT)
  - Baseline pump parameters
  - Pertinent alarm history

Infection Prevention
- Discuss perioperative antibiotic prophylaxis with surgical team/heart failure team
- Maintain aseptic technique for all invasive procedures
- Utilize standard precautions

Blood Products
- Discuss blood product utilization and relevant lab goal parameters with patient's heart failure team/surgical team
- Determine BTT vs DT

Blood Pressure Monitoring *
- Determine mode of BP monitoring
  - Invasive vs non-invasive

*Refer to the LVAD Blood Pressure Monitoring Decision Tree tool

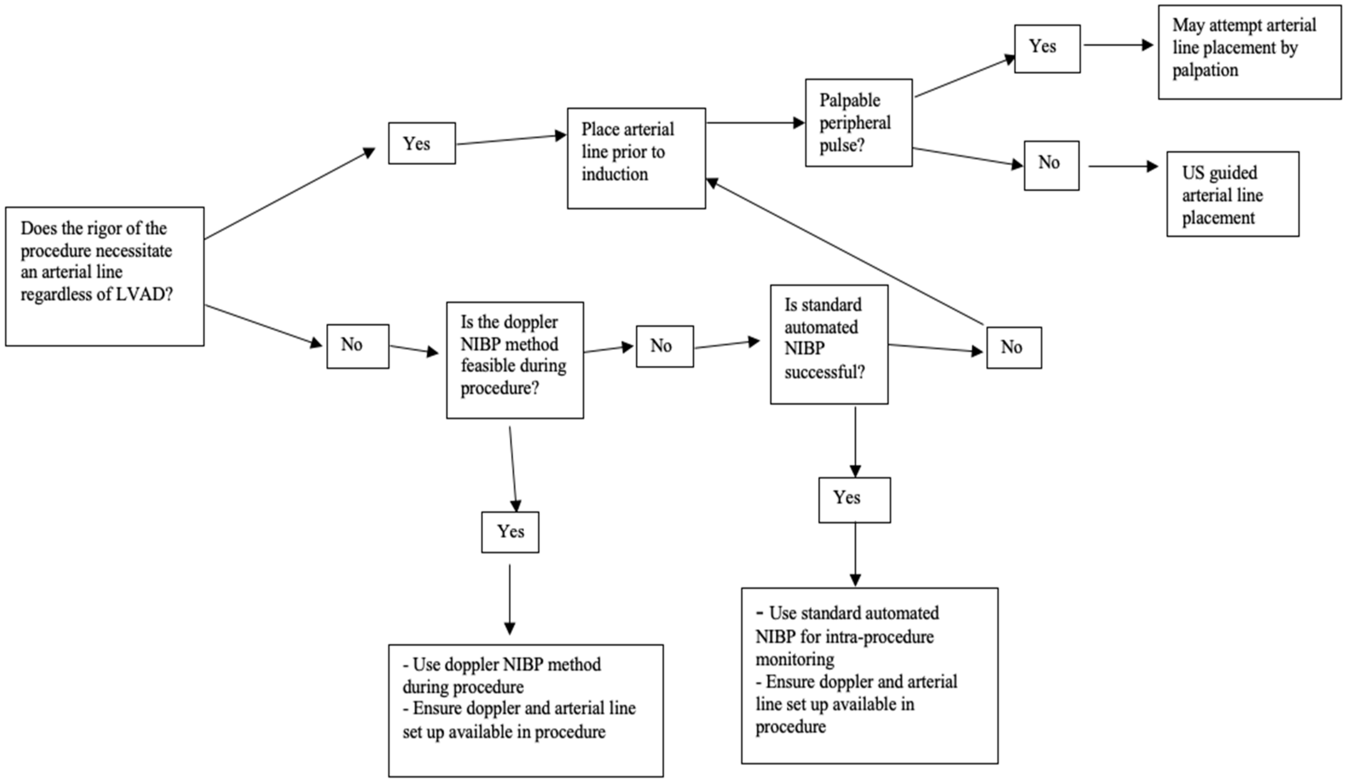
Abbreviations: PT, prothrombin time; INR, International Normalized Ratio; aPTT, activated partial thromboplastin time.

LVAD Blood Pressure Monitoring Decision Tree

The LVAD BP Monitoring Decision Tree (**Figure 2**) is a systematic process designed to guide the provider in determining whether to use invasive or non-invasive BP monitoring for each LVAD patient. Standardizing the decision-making process helps reduce unnecessary arterial line placement in LVAD patients.

The decision tree begins with determining if the rigor of the procedure requires an arterial line regardless of LVAD status. For procedures with increased risk of blood loss and hypotensive episodes, continuous BP monitoring will lead to more timely treatment (Level IVB and VA evidence) (Chung, 2018; Pour-Ghaz et al., 2019). If the procedure alone does not necessitate arterial line placement, the decision tree prompts the provider to attempt a NIBP measurement. If the benefits of invasive BP monitoring outweigh the risks, the provider is prompted to place an arterial line preinduction (Level IIIB, IVB, VA evidence) (Barbara et al., 2017; Goudra & Preet, 2013; Mathias et al., 2017; Pour-Ghaz et al., 2019; Stone et al., 2016).

Figure 2
LVAD Blood Pressure Monitoring Decision Tree



Abbreviations: NIBP, non-invasive blood pressure; US, ultrasound

LVAD Preanesthesia Toolkit Knowledge Dissemination

Following Toolkit development, a pilot implementation for the initiative involved a 2-step process of education and application. Project leaders created an LVAD Preanesthesia Toolkit electronic education module for SRNAs and Certified Registered Nurse Anesthetists (CRNAs) practicing at the medical center. The education module was made accessible through an online application system, which enabled direct anonymous responses and verification of learner understanding via direct response rate. The multidisciplinary panel of experts updated and approved the final draft education module, which included access to the VaPA tool, the LVAD BP Monitoring Decision Tree, and evidence-based details pertaining to each tool. Post education, the Toolkit was implemented for clinical utilization.

Results

Anesthesia Provider Education

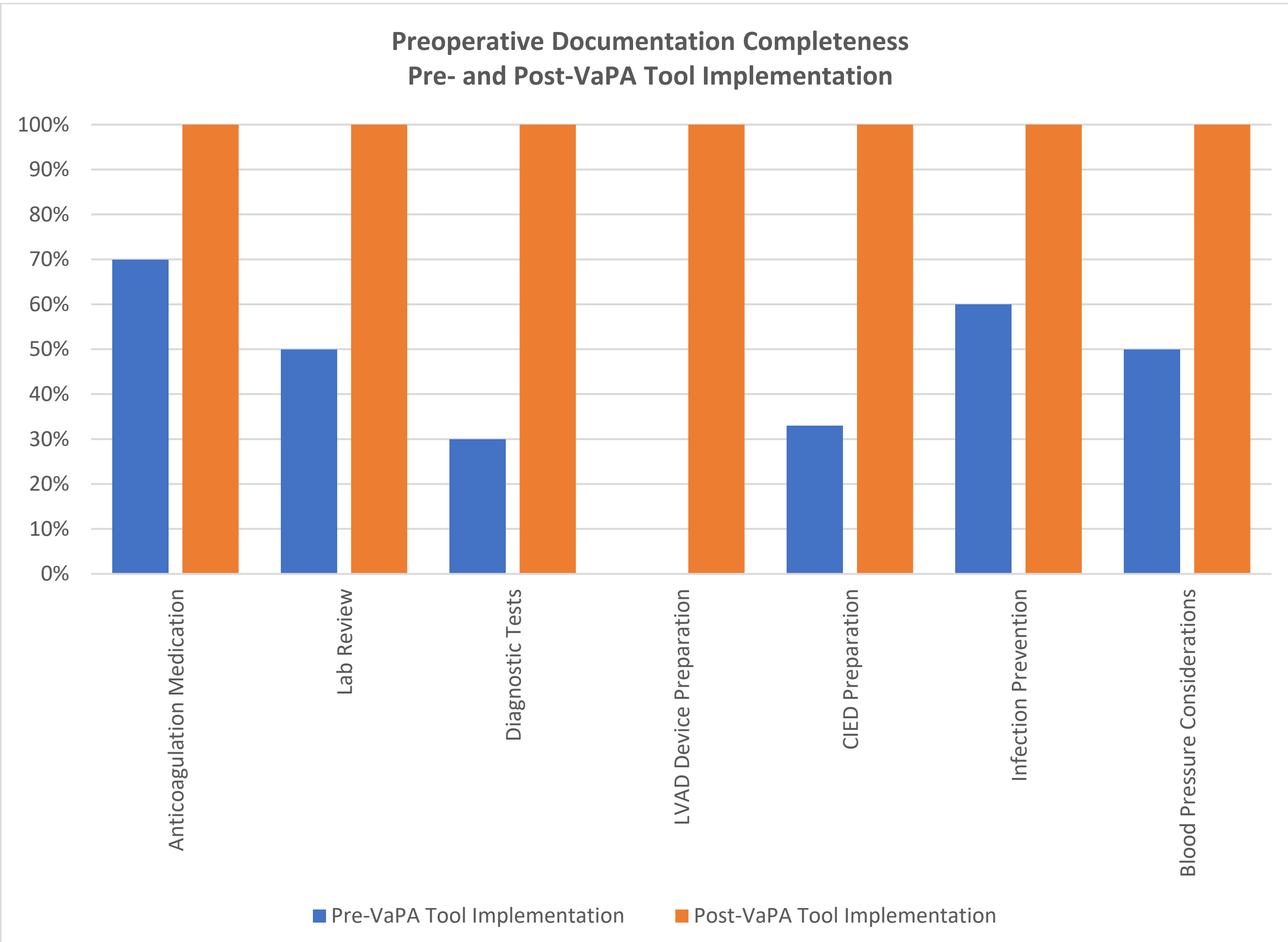
Project leaders sent the LVAD Preanesthesia Toolkit electronic education module to 48 SRNAs and 44 CRNAs in the institution through an online application system that allowed for anonymous retrieval of the education module and data collection via email. The team tracked the number of respondents who read the module on a weekly basis across the 8 weeks of the educational rollout. After 4 weeks, SRNAs and CRNA received a reminder email with the link to the education module. At 4 weeks, 17.4% (n=16/92) of SNRAs and CRNAs responded, indicating a review and understanding of the education module. At 8 weeks, 27.2% (n=25/92) of SRNAs and CRNAs had reviewed and confirmed understanding of the LVAD Preanesthesia Toolkit.

LVAD Preanesthesia Assessment (VaPA) Tool

Upon completion of the staff education plan, measurement of VaPA tool utilization occurred via EHR chart review. Over a 5-month data collection period post implementation, there were a total of 2 noncardiac procedures performed in patients with LVADs. Figure 3 shows baseline data taken from 10 preoperative anesthesia assessments in LVAD patients who underwent noncardiac procedures prior to VaPA tool implementation compared to data from the 2 preoperative anesthesia assessments performed post-VaPA tool implementation. The post-implementation assessments for both procedures showed 100% documentation completeness for all VaPA tool elements.

Figure 3

Documentation of Preanesthesia Assessment Components Pre- and Post-implementation of the VaPA Tool



LVAD Blood Pressure Monitoring Decision Tree

The LVAD Blood Pressure Monitoring Decision Tree was not implemented into clinical practice during the time frame allotted for this quality improvement initiative. Time restraints, in addition to a lack of education dissemination for users, remain two obstacles for the implementation of the decision tree tool. Therefore, authors were unable to evaluate of the tool to determine its effectiveness in achieving the desired goals of using a systematic approach to determining the best blood pressure (BP) monitoring process and decrease the invasive BP monitoring rate for LVAD patients. However, the authors felt that inclusion of the evidence-based tool in this article serves as a valuable resource to anesthesia providers. For this facility, improved education and implementation of the LVAD Blood Pressure Monitoring Decision Tree into clinical practice will be necessary to fully achieve desired outcomes.

Discussion

The results of the LVAD Preanesthesia Toolkit initiative indicate that improved practice is possible for LVAD patients undergoing noncardiac procedures. Evaluation of post-implementation data showed that anesthesia providers used the formalized assessment checklist in the VaPA tool and documented all essential components of the anesthesia assessment in the EHR. Effective implementation of a checklist plays a major role in provider adoption and utilization. Guideline utilization is beneficial in complex environments and, when adhered to, can optimize patient safety and outcomes (Turkelson & Keiser, 2017). The World Health Organization (WHO) implemented the WHO Surgical Safety Checklist in 2008 as part of a global initiative to improve patient safety outcomes, resulting in a 64% reduction in the complication rate and a 53% decrease in the mortality rate across multiple countries (Haugen et al., 2019). Commonly adopted and utilized by surgical providers worldwide today, the WHO Surgical Safety Checklist provides a prime example of the benefits of checklist use in healthcare. As checklists increase in popularity, significant reductions in morbidity and mortality continue to be shown across multiple studies of checklist use in clinical practice (Clark et al., 2012; Treadwell et al., 2014).

In this project, an online education module introduced the VaPA tool and was the primary source for initial provider awareness and education. E-learning, defined as education delivered electronically via the internet, has become increasingly popular because of its low cost, ability to be distributed widely, accessibility, and convenience of independent learning (Vaona et al., 2018). Although e-learning requires increased self-discipline and may not match the learning styles for all users, studies show similar positive effects to traditional learning strategies and large positive effects when compared with no learning intervention (Mazzoleni et al., 2012; Vaona et al., 2018). Barriers to effective checklist implementation often result from poor accessibility to checklist resources, provider misunderstanding of checklist use, and lack of provider participation, all possibly the result of inadequate education (Vaona et al., 2018).

The uniqueness and complexity of the LVAD patient population involves a wide range of specialists and collaborative care, and open communication among team members and a clear understanding of the goals of care for each patient are important to ensure patient safety. CRNAs are held to the AANA Standards for Nurse Anesthesia Practice; standard 14, a Culture of Safety, places an emphasis on high-quality, safe, and patient-centered anesthesia care through open, respectful collaboration among interdisciplinary teams (AANA, 2019). Improvement in communication and teamwork are shown in up to 77% of checklist users (Treadwell et al., 2014). Utilization of the VaPA tool during the preanesthesia assessment ensures the transfer of necessary information within the patient's care team and helps minimize perioperative risks pertaining to the LVAD patient.

While the effectiveness of the BP Monitoring Decision Tree was not determined within the time frame of this project, there are future plans to implement the use of the decision tree in noncardiac procedures.

Limitations

The LVAD initiative was developed and implemented during the COVID-19 pandemic when the LVAD program was in a startup phase and the number of in-hospital medical and surgical services was greatly decreased. This resulted in a low volume of LVAD patients undergoing noncardiac procedures during the post-implementation phase, which in turn limited the outcome data of the LVAD Preanesthesia Toolkit initiative and decreased our ability to determine the degree to which desired outcomes were achieved. Ongoing data collection and project replication will strengthen the results of this pilot.

Because this project was conducted during the COVID-19 pandemic, in-person staff education on the Toolkit was not an option. The education module utilized in this project was unable to reach all CRNAs and SRNAs, diminishing awareness of the VaPA tool. Additionally, LVAD BP Monitoring Decision Tree education was not implemented, but dissemination of the evidence-based tool and description of its development can inform other clinicians who are seeking an appropriate decision-making tool in their healthcare systems.

Next Steps

Ongoing quality improvement initiatives surrounding the identified practice gaps in this paper can involve a two-pronged approach. One avenue is to continue to determine the effectiveness of the LVAD Preanesthesia Toolkit in decreasing patient morbidity and mortality through a risk analysis. While the VaPA tool is effective in guiding the preanesthesia assessment, the ongoing impact on patient outcomes still needs to be determined. The other avenue is to implement educational modules for anesthesia providers regarding use of the LVAD BP Monitoring Decision Tree and integrate the tool into clinical practice to determine the best method for monitoring blood pressure during non-cardiac LVAD cases. The initiative implementation team plans to improve the education for relevant providers to assist them in understanding and adopting both the VaPA tool and the LVAD BP Monitoring Decision Tree by using appropriate teaching modalities that accommodate all learning styles such as in-person informational sessions and virtual education sessions. The overall future goal is to focus on Plan Do Study Act (PDSA) cycles for ongoing evaluation of the utilization of both tools in the LVAD Preanesthesia Toolkit.

Conclusion

Patients with LVADs are complex and challenging for the anesthesia provider. The development and implementation of the LVAD Preanesthesia Toolkit provided evidence-based resources for anesthesia providers to enhance the care of this vulnerable patient population. In particular, the continued utilization of the preanesthesia assessment checklist promises to promote safety and improve patient outcomes for patients with LVADs undergoing noncardiac procedures.

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Appendix

Level of Evidence and Quality for LVAD Preanesthesia Toolkit

Bibliographic Information	Design/Methods	Level of Strength	Quality of Evidence
ASA, 2012	Systematic Review	III	A
Barbara et al., 2017	Literature Review	IV	B
Bennett et al., 2010	Quasi-experimental	II	A
Chung, 2018	Literature Review and Expert opinion	V	A
Dalia et al., 2017	Literature Review	V	A
Degnan et al., 2016	Qualitative Retrospective Cohort Study	III	B
Firstenberg et al., 2011	Quality Improvement Initiative	IV	C
Fleisher et al., 2014	Systematic Review	III	A
Goudra & Preet, 2013	Qualitative Retrospective Cohort Study	III	B
Khoo, 2010	Literature Review	V	A
Lanier et al., 2013	Quasi-experimental Non-randomized Control and Comparison Group	II	B
Mathias et al., 2017	Qualitative Retrospective Cohort Study	III	B
Peacher, 2016	Literature Review	V	A
Pour-Ghaz et al., 2019	Literature Review	V	A
Riha et al., 2010	Literature Review	V	A
Slininger et al., 2013	Literature Review	V	A
Stone et al., 2016	Qualitative Retrospective Cohort Study	III	B
Yeap et al., 2019	Randomized Control Trial	I	A