DERLEME REVIEW

DOI: 10.5336/cardiosci.2020-75535

Major Complications and Nursing Care of Patients Implanted Left Ventricular Assist Device

Sol Ventrikül Destek Cihazı İmplante Edilen Hastalarda Major Komplikasyonlar ve Hemşirelik Bakımı

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ABSTRACT Heart failure is an important public health problem associated with morbidity, mortality and health expenditures and there are various options in its treatment. Left ventricular assist devices are a frequently used treatment alternative to heart transplantation in end-stage heart failure. Left ventricular assist devices are used both as a temporary treatment until a suitable donor is found in patients who are waiting for a heart transplant, and as a lifelong treatment when the patient is not suitable for a heart transplant. Although the survival rates are quite high in this treatment option, clinical follow-up and systematic care of patients are critical. Although left ventricular assist devices are a life-saving treatment option, these patients may experience some major complications due to advanced heart failure, open heart surgery technique and implanted device. Major complications seen in these patients are bleeding, cardiac arrhythmias, infections and neurological events. These complications affect quality of life and survival. Therefore, management of complications in the postoperative period becomes the focal point in patients who have implanted left ventricular assist device. Although these complications are not easy to manage, nurses should be equipped with advanced knowledge about the causes, symptoms, and appropriate nursing care of these complications. At the same time, nurses need to know about the technology of left ventricular assist devices for the management of these complications. In this article, major complications seen after left ventricular assist device implantation and nursing care are discussed.

Keywords: Heart-assist devices; nursing care; postoperative complications

ÖZET Kalp yetersizliği morbidite, mortalite ve sağlık harcamaları ile ilişkili önemli bir halk sağlığı sorunu olup tedavisinde çeşitli seçenekler bulunmaktadır. Sol ventrikül destek cihazları son evre kalp yetersizliğinde kalp nakline alternatif sık kullanılan bir tedavi seçeneğidir. Sol ventrikül destek cihazları hem kalp nakli bekleyen hastalarda uygun donör bulununcaya kadar geçici bir tedavi olarak hem de hastanın kalp nakli için uygun olmadığı durumlarda ömür boyu sürecek bir tedavi olarak kullanılmaktadır. Bu tedavi seçeneğinde sağ kalım oranları oldukça yüksek olmakla birlikte hastaların klinik takip ve sistematik bakımları kritik önem taşımaktadır. Sol ventrikül destek cihazları hayat kurtarıcı bir tedavi seçeneği olmakla birlikte bu hastalar ileri evre kalp yetersizliği, açık kalp cerrahisi tekniği ve implante edilen cihaz nedeniyle major komplikasyonlar yaşayabilirler. Bu hastalarda görülen major komplikasyonlar kanamalar, kardiyak aritmiler, enfeksiyonlar ve nörolojik olaylardır. Bu komplikasyonlar yaşam kalitesini ve sağ kalımı etkilemektedir. Bu sebeple sol ventrikül destek cihazı implante edilen hastalarda, ameliyat sonrası dönemde komplikasyonların yönetimi odak nokta haline gelmektedir. Bu komplikasyonların yönetimi kolay olmamakla birlikte hemşireler bu komplikasyonların nedenleri, belirtileri ve uygun hemşirelik bakımı hakkında ileri düzeyde bilgi ile donatılmalıdır. Aynı zamanda bu komplikasyonların yönetimi için hemşirelerin sol ventrikül destek cihazlarının teknolojisi hakkında da bilgi sahibi olması gerekmektedir. Bu makalede sol ventrikül destek cihazı implantasyonundan sonra görülen major komplikasyonlar ve hemşirelik bakımı ele alınmaktadır.

Anahtar Kelimeler: Kalp destek cihazları; hemşirelik bakımı; postoperatif komplikasyonlar

Heart failure is a major public health problem affecting more than 26 million individuals worldwide and more than 2.5 million individuals in Turkey. Various medical and surgical treatment methods are used in the treatment of heart failure.[1,2] Heart transplantation is used as the gold standard for the treatment of patients at the final stage of heart failure. However, this treatment cannot be implemented for many patients because of the insufficient number of donor hearts.[3-6] For this reason, implantation of Left Ventricular Assist Devices (LVADs) has overtaken heart transplantation in the treatment of end-stage heart failure and become an increasingly used treatment option.[3,6-8] According to the report of The Interagency Registry for Mechanically Assisted Circulatory Support (2015), there are more than 13.000

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Peer review under responsibility of Turkiye Klinikleri Cardiovascular Sciences.

Received: 30 Apr 2020 ***Received in revised form:*** 09 Jul 2020 ***Accepted:*** 19 Jul 2020 ***Available online:*** 09 Dec 2020

patients with left ventricular assist devices.[9] In Turkey, according to the Cardiology-Cardiovascular Consensus Report (2016), about 550 mechanical assist devices are implanted and the majority of them are left ventricular assist devices.[10] LVADs are used for various purposes such as healing (bridge to recovery), bridge to transplantation and lifetime (destination) therapy.[4,11-15] As well as being used until an appropriate heart for transplantation can be found, LVADs have become an important option for patients with end-stage heart failure.

Although LVADs are a life-saving treatment option, they also entail dramatic lifestyle changes, a requirement for effective discharge training and a high rate of complications.[12,14-17] In recent years, a new generation of continuous flow devices have replaced the older pulsatile flow devices, which significantly reduced the incidence of complications.[11,16,18,19] However, since the rate of more LVAD implantations has increased, complications still constitute an important problem.[6,11,16,20]

According to the report of The Interagency Registry for Mechanically Assisted Circulatory Support (2015), which was founded to collect information about mechanical support devices, the most common complications after LVAD implantation are haemorrhages, cardiac arrhythmia, infections and strokes (Table 1).[9]

The nursing care for patients with LVADs should focus on the postoperative prevention and management of complications.[12,21,22] This article describes most common complications of LVAD patients and their nursing care.

TABLE 1: Complications and adverse events seen after LVAD implantation.

Bleeding
Cardiac/vascular problems
Cardiac arrhythmia
Right heart failure
Myocardial infarction
Pericardial drainage
Hypertension
Arterial non-CNS thrombosis
Venous thrombotic event
Haemolysis
Infection
Stroke
Renal dysfunction
Hepatic dysfunction
Respiratory failure
Wound dehiscence
Psychiatric episode

HAEMORRHAGES

Haemorrhage is the most common postoperative complication observed among the LVAD patients.[9,18,23] Haemorrhages are described by their causes and the organ in which they originate, as follows:

HAEMORRHAGES DUE TO COAGULATION DISORDER

As with other open heart surgery patients, it is important to distinguish between haemorrhages due to coagulation disorder and haemorrhages due to surgery.[21] In order to recognize haemorrhages due to coagulation disorder, monitor coagulation tests such as prothrombin time, partial thromboplastin time, platelet count, fibrinogen levels and dose of recombinant activated factor VII should be monitored.[21,24] The causes of haemorrhage due to coagulation include factors such as anticoagulant for thrombosis prophylaxis, anti-platelet and anti-aggregant drug use, consumption of foods and herbal products that can alter clotting and platelet functions, previous history of haemorrhage, and hypothermia.[11,15,22] In the preoperative period, patients with heart failure are usually prone to bleeding due to hepatic dysfunction caused by renal failure and hepatic congestion.[15,22] The signs and symptoms of haemorrhage due to coagulation disorder are: more than 200 ml of drainage per hour from chest tubes, hypotension, tachycardia, tachypnea, decreasing urine output, changes in mental state, sweating, longer capillary backfill times, reduced LVAD flow, hepatomegaly, jugular venous distension and petechiae.[11,12,15] The treatment of these haemorrhages aims to reverse anticoagulation; and patients receive blood product transfusions according to coagulation test results.[6,11,21] Bruckner et al. recommended coagulation factor VII is also as a treatment option since it shortens prothrombin time

and activates partial thromboplastin time, reducing the need for blood transfusions.[24]

SURGICAL BLEEDING

Surgical bleeding is seen in 31% of the patients with LVADs, which provide continuous flow, most commonly on the first day.[20,23] The causes of surgical bleeding are prolonged duration of surgery carried out with cardiopulmonary bypass technique, common surgical dissection, failure to perform appropriate anastomoses, formation of driveline tunnels and preperitoneal pockets after heparinisation, unnecessary abdominal interventions, and hypertension.[15,21,22] Instead of traditional mechanical haemostatic methods, fibrin adhesives should be used along the suture lines to prevent haemorrhages due to surgery.[20,25] Although the signs and symptoms (hypotension, tachycardia, tachypnea, decreased urine output, changes in mental status and low flow rates on LVAD monitor) of the haemorrhages due to surgery are similar to those of the haemorrhages due to coagulation disorder, sudden and intense bleeding from the drainage tubes and drainage output of 200 mL per hour mostly indicates surgical bleeding.[4,11,18,19] The treatment options for surgical bleeding include another surgery for a review of anastomoses and restoration of haemostasis, blood product transfusions and leaving the sternum open for 24 hours using appropriate techniques, which is a method used for ongoing intraoperative hemorrhage.[15,21,26-28]

GASTROINTESTINAL HAEMORRHAGES

Another type of haemorrhage observed after LVAD implantation is gastrointestinal hemorrhage.[12,21,23,28] Gastrointestinal haemorrhage is seen in 20% of the patients with LVADs, most commonly on the 33th day.[23,29] It is an important cause of rehospitalisation in the first month after implantation and significantly increases the morbidity and mortality rates.[12,30,31] The risk factors of gastrointestinal haemorrhage include advanced age, male gender, history of gastrointestinal haemorrhage; gastrointestinal erosions or ulceration, the use of antithrombotics, anticoagulants, antiplatelets and herbal and non-steroid anti-inflammatory drugs, right ventricular dysfunction, an ejection fraction of less than 30% after LVAD implantation.[12,30-33] The factors related to LVADs are also important for gastrointestinal haemorrhage. Those are;

- Von Willebrand syndrome, which may develop due to increased tension of rotating impellers and reduced pulsatility in patients with LVADs that provide continuous flow.[12,34,35]
- Arteriovenous malformations in the gastrointestinal tract in patients with LVADs that provide continuous flow.[33,36]
- Hypoperfusion caused by continuous blood flow in the intestines, which causes hypoxia, vascular dilatation and angiodysplasia.[12,31]

Gastrointestinal haemorrhage in LVAD patients shows similar symptoms to those of other patients: hematemesis, melena, faecal occult blood, rectal bleeding, weakness, fatigue, dizziness, fainting, and decreased haemoglobin, haematocrit, platelet, blood urea nitrogen and active bleeding at the time of endoscopy or colonoscopy.[30,36] The treatment options for patients with gastrointestinal haemorrhages include fresh frozen plasma, antiplatelet therapy, reversing anticoagulation with inactive prothrombin complex and vitamin K, treating hypovolemia with liquids, and blood product transfusions. Additional drugs such as somatostatin (Octreotid), somatostatin analogue or desmopressin acetate (Minirin) can also be used for treatment.[12,21,37-39] In addition, endoscopic treatment methods can be used to identify the source of haemorrhage and stop it.[30,31,40]

It is important to plan the nursing care for all these haemorrhage complications. These patients generally have at least two chest drains, and the amount of drainage should be monitored every hour for signs of bleeding.[22] Hypertension can exacerbate or precipitate mediastinal bleeding and can occasionally cause dehiscence of arterial suture lines. Since hypertension may be associated with pain, it must be evaluated and managed using sedatives, analgesics or both.[6,22] Patients with LVAD implantations experience hypothermia due to the surgical technique and cold operating rooms. Since sudden temperature increases will cause vascular dilatation, patients with hypothermia should be warmed slowly using appropriate heating techniques.[22] For the same reason, it is important to ensure that blood products and intra-

venous fluids are administered at the appropriate temperature.[15,41] Excessive blood transfusion may lead to infections, right heart distension caused by cytokine release and increased costs.[15,21,41] It may also cause pulmonary hypertension, which may lead to right heart failure.[15,41,42] This may elevate the patient's antibodies and prevent a heart transplantation.[15,42]

Pumping speed, flow, power and pulsatility index values should be followed on the LVAD monitor since they may decrease due to hemorrhage.[12,43] The blood and pulse pressure of the patients implanted with LVADs that provide pulsatile flow were similar to those of the other patients because of the pulsatility. However, these values were different in the patients implanted with LVADs that provide continuous flow due to the absence of pulsatile flow.[22] The signs and symptoms of haemorrhages should be monitored considering these differences to ensure correct nursing care. Patients with LVADs that provide continuous flow show no arterial waveform because of the absence of pulsatile flow; therefore, among the blood pressure values, their mean arterial pressure is monitored and measured through invasive methods or Doppler ultrasonography.[12,22,38,44-46] For these patients, a mean arterial pressure of 70 mmHg to 80 mmHg or equal to 80 mmHg are considered to be normal, which fall in the presence of hemorrhage.[12,38,42,47] Patients with LVADs that provide continuous flow have lower pulse pressures than 15 mmHg. Therefore, their peripheral pulses are weak and not palpable.[12,48] Peripheral pulses are measured using Doppler ultrasonography on the temporal, carotid, brachial, radial, femoral, popliteal, dorsalis pedis, posterior and tibial arteries.[12,46,47] Blood and pulse pressure reduce in the presence of haemorrhage. Knowledge about the normal values and the ability to make accurate measurements are important elements in effective nursing care.

CARDIAC ARRHYTHMIAS

Cardiac arrhythmia is a commonly seen complication (56-59%) in patients with LVAD implantations.[9,12,26] Of the cardiac arrhythmia types, 20% are atrial and 30% are ventricular arrhythmias.[49] Although ventricular arrhythmias are more common, atrial arrhythmias are also commonly observed within the first 60 days after LVAD implantation due to myocardial inflammatory response.[37,49] The causes of arrhythmias in LVAD patients are mechanical trauma caused by the LVAD entrance cannula in addition to the presence of heart failure, complete decompression of the ventricle of the LVADs with continuous flow, electrolyte imbalances, and drugs.[22,50,51] The symptoms of atrial arrhythmia include reduced activity tolerance, increased fatigue, fluid retention and increased dyspnoea. On the other hand, arrhythmias may enhance the risk of stroke and pump thrombosis. On the other hand, the symptoms of ventricular arrhythmias include dizziness, presyncope, syncope, intermittent flutter and sudden cardiac death.[34,47,49] In both ventricular and atrial arrhythmias, decreases in parameters especially pulsatility index and flow may be observed on the LVAD monitor.[12,33,37,52] Beta blockers and, if they are not effective, amiodarone (Cordarone) are used to treat atrial arrhythmia. Amiodarone (Cordarone), lidocaine and dofetilide (Tikosyn) are preferred for the treatment of ventricular arrhythmia.[4,12,33,53] Since atrial and ventricular arrhythmias can cause thromboembolism, it is very important to use anticoagulation in addition to the treatment.[46,50,54] Most of these patients had cardiac arrhythmia due to heart failure before the LVAD implantation and have an implanted cardioverter defibrillators (ICD).[12,55] The ICD, which is deactivated during the intraoperative period, is activated after the LVAD implantation, before the patients are discharged from the intensive care unit and is used to treat cardiac arrhythmias.[6,12,22,33]

Cardiac arrhythmias in LVAD patients can cause mortality, which makes timely intervention important.[12] Their 12-lead electrocardiography should be carefully monitored.[37,50,51,53] In the presence of arrhythmias caused by imbalanced potassium and magnesium, the missing electrolytes must be replaced.[22,32,33] At the same time, it is necessary to determine whether there is an ICD and to make a risk assessment for arrhythmias before surgery, since these are widely used in these patients.[32,33,38] In the presence of an ICD, it is important to eliminate anxiety that may be caused by shock, which on the other hand may be caused by ventricular tachycardia attacks due to an increased release of catecholamines.[12]

INFECTIONS

Infections are one of the most important complications that affect the success and long-term use of LVAD implantations and are the second leading cause of death.[46,56-58] Infections usually occur three months after implantation and may require the patient to be rehospitalized.[15,22,46] The incidence of LVAD-related infections ranges from 30% to 50%.[7] The most common type of infection, sepsis, is seen approximately in 18% and another common type of infection, driveline infection, is seen in 17%.[59]

SEPSIS

Patients with LVADs have a high possibility of blood circulation infection and subsequent sepsis during the perioperative period.[9,12,59] The causes of blood circulation infection and subsequent sepsis are large body mass index, malnutrition, diabetes, metabolic abnormalies, long-term hospitalization, major surgery and the implantation of foreign objects into the body.[11,17,22,60] The symptoms of sepsis are fever and leucocytosis. In serious cases, sepsis can cause septic shock and haemorrhagic stroke.[11,12] The evaluation of blood pressures and fluid management is more difficult in LVAD patients than in other sepsis patients. The treatment of sepsis includes broad spectrum antibiotic treatment initiated by swab cultures from the blood and driveline output region, correction of hypovolemia, hypotension and vasodilatation, oxygen therapy, corticosteroids, immunoglobulins, selenium, glucose control, bicarbonate therapy, deep vein thrombosis prophylaxis, stress ulcer prophylaxis, nutrition, and surgical interventions such as LVAD replacement used in the management of medicine-resistant infections.[12,13,38]

Nursing care for sepsis in LVAD patients includes monitoring the signs and symptoms of sepsis. In addition to this, all invasive procedures should be performed in accordance with aseptic techniques. Invasive catheters, intubation tubes and drains should be removed as soon as possible. Early mobilization, proper nutrition (enteral and parenteral) and deep breathing and coughing exercises using spirometry should be ensured and blood sugar level should be checked.[22,33,38,61]

DRIVELINE INFECTIONS

Driveline infections are commonly seen late-onset infections in LVAD patients.[11,62,63] The risk factors for driveline infections are long-term LVAD use, obesity, insufficient nutrition, advanced age, comorbidities such as diabetes mellitus, chronic kidney disease and depression, lack of patient education, improper wound care, trauma, inappropriately tunnelled drivelines, the presence of drain tubes, and contamination during the intraoperative or perioperative periods.[11,57,64]

It has been determined that *Staphylococcus aureus* is the most common cause of driveline infections.[65] Driveline infections are classified as superficial and deep.[66] The symptoms of superficial infections include the signs of local infection such as erythema, pain, oedema, temperature, and purulent discharge in the subcutaneous tissues surrounding the device or at the cutaneous outlet. The symptoms of deep infections, on the other hand, include the signs of systemic infection such as fever and leucocytosis, which can cause bloodstream infections.[11,15,57,66,67] Increasing the frequency of dressing changes, antibiotic therapy, local debridement and clinical controls are recommended for the treatment of superficial driveline infections.[64,66,67] Opening the driveline tunnel and draining the infection, vacuum-assisted sealing, removing the infected tissue along the driveline, formation of new tissue with rectus muscle, and for long-term infections where these procedures completely fail, providing a new percutaneous exit by moving the driveline to the intraperitoneal space are recommended for the treatment of deep infections.[64,67]

The nursing care for driveline infections in LVAD patients requires a focus on nutrition, driveline dressing and patient education.[57,61] Enteral or parenteral nutrition should be started in the early postoperative period after identifying the causes of malnutrition, which adversely affect wound healing.[15,61] The driveline exit side should be cleaned using 1-2% chlorhexidine gluconate, hydrogen peroxide, povidone-iodine or the company's recommended antiseptics, and then it should be rinsed using 0.9% sodium chloride and sealed with sterile gauze after the wound has dried.[19,37,61,68] Recently, the driv-

eline outlet region is commonly closed with a sterile gauze; and foam dressings and dressings with merbromin have been proven to reduce the risk of driveline infections.[65,69] If possible, dressing changes should be started within 24 to 48 hours after the operation.[70] Studies have shown no relationship between the frequency of dressing changes and driveline infections, and it is recommended that driveline dressings be performed by specially trained nurses every day for the first 10 days, 3 times a week from the 11th to the 21st day, and then twice a week.[70-72] Patients and their families should be educated about dressing changes and should be informed about the necessary materials before discharge. Patients should be informed about the signs and symptoms of driveline infections and told to visit the hospital if they suspect a problem.[70]

NEUROLOGICAL EVENTS

Patients with LVAD implantations are at risk of stroke. Determining the type of stroke is important for the treatment, and the ischemic and haemorrhagic strokes are distinguished through computed tomography.[12,21,45] The ratio of ischemic stroke is 7.5%, and the ratio of haemorrhagic stroke is 7.8% in these patients.[73] The causes of ischemic stroke include diabetes, hypotension, low pump flow, development of heparin induced thrombocytopenia, previous stroke, pump thrombosis and thromboembolic events related to the prothrombotic state associated with sub-therapeutic anticoagulation or activation of the immune system. The causes of haemorrhagic stroke include ischemic stroke, high dose anticoagulation, antiplatelet therapy, infection and hypertensive conditions with a mean arterial pressure above 90 mmHg.[6,12,13,33,42,45,74] Both types of stroke impair motor, sensory and cognitive functions.[22,33,75] Intra-arterial embolectomy is used to treat ischemic strokes caused by large vessel occlusions that have no infarct area seen in computed tomography.[45,76,77] To treat haemorrhagic strokes, anticoagulation should be reduced or reversed in order to limit continued bleeding. Patients' international normalized ratio (INR) should be kept between 1.5 and 2.5, which requires intravenous administration of vitamin K or frozen plasma.[12,13,21] Another point to be considered in the treatment of haemorrhagic strokes is to resume the anticoagulant and anti-platelet therapy within two weeks after the findings are stable in order to prevent pump thrombosis.[75]

Nursing care for ischemic and haemorrhagic stroke complications in LVAD patients includes monitoring coagulation and blood pressure, and conducting neurological evaluations using the Glasgow Coma Scale.[12,21,75] For this purpose, all LVAD patients should initially be evaluated for neurological symptoms, and this evaluation should be repeated at regular intervals. Any changes in the motor, sensory and cognitive functions should be detected as soon as possible. Patients and their relatives should also be informed about the signs and symptoms of neurological changes, and the situations they need to report their physician or nurse.[22,76]

CONCLUSION

The number of LVAD patients continues to increase every day; however, the long-term use of such devices also entails various complications. Postoperative complications are closely correlated with quality of life and survival, which makes it very important to manage them correctly. Nurses play a critical role in the detection, treatment and management of these complications. Therefore, they need physiological knowledge and ability of critical thinking. The increased number of LVAD implantations has led to an increasing possibility that healthcare workers with no education or experience on LVADs encounter patients with LVAD implantations. In such cases, understanding and managing LVAD patients becomes an important issue. This review aims to decrease LVAD patient complications and increase patients' quality of life and survival by ensuring information sharing among the healthcare professionals who have no training and experience, clinical nurses and researchers.

Source of Finance

During this study, no financial or spiritual support was received neither from any pharmaceutical company that has a direct connection with the research subject, nor from a company that provides or produces medical instruments and materials which may negatively affect the evaluation process of this study.

Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

Authorship Contributions

Idea/Concept: *Fatma Demir Korkmaz;* ***Literature Review:*** *Nihal Çeliktürk;* ***Writing the Article:*** *Fatma Demir Korkmaz, Nihal Çeliktür;* ***Critical Review:*** *Fatma Demir Korkmaz, Nihal Çeliktürk.*

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