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Review

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# POSTOPERATIVE MANAGEMENT OF PATIENTS AFTER VAD IMPLEMENTATION

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## Summary

After the implantation of the left ventricular assisted device (LVAD), patients are admitted in intensive care unit (ICU). During the period of first several days, the goal of the postoperative care is to stabilize the patients' hemodynamics. Monitoring the continuous cardiac output, filling volumes and outflow resistance is necessary for the proper functioning of the pump. The use of pulmonary artery catheter and the transesophageal echocardiography are primary procedures. During the operation of the left ventricular support, the measuring of proper ventricular function and the early recognition of its dysfunction is important for a positive outcome. Further potential complications in connection with these patients are an increased risk of hemorrhage and thromboembolism. The infection of drivelines and devices in the early postoperative period occurs in up to 40 % of these patients. In case of a cardiac arrest, a special procedure has to be performed in patients in whom LVAD was implanted. Finally, we have shown the anesthesiologic management in cases when patients with LVAD have to undergo non-cardiac surgery.

**Keywords:** LVAD; hemodynamics; TEE; LVAD; noncardiac surgery

After the implementation of ventricular assisted device (VAD), patients are admitted to the intensive care unit (ICU). Recommendations for anesthetic approach during the surgery suggest the use of total intravenous anesthesia (TIVA), in order to minimize the hemodynamic impact; e.g. TIVA technique using an opioid; benzodiazepine such as midazolam; and long-acting muscle relaxant. Halogenated anesthetic agents may be used as supplementation to intravenous anesthesia, but only in patients who can tolerate them hemodynamically. In many centers, as well

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as in ours, there is no advantage to attempting a “fast-track” approach, since these patients are required to remain intubated overnight or longer, regardless of the type of device implanted. During this period, it is important to stabilize the patients’ hemodynamics and coagulation, and perform the transesophageal echocardiography to check VAD and heart function.

## **Hemodynamics**

In all the patients undergoing the implantation of VAD, continuous hemodynamic monitoring has to be implemented. It is recommended to implant a catheter for measuring both the continuous cardiac output (CCO) and the mixed venous saturation (SvO<sub>2</sub>). The hemodynamic management of an LVAD patient is important, as the pump function of each device depends on both the filling volume and the outflow resistance. HeartMate, Novacor, and Thoratec pumps all exhibit sensitivity to changes in the preload, especially when functioning in the “fill-to-empty” mode. While these devices exhibit no Starling effect with respect to stroke volume or stroke work, they can only pump the volume delivered to them, and inadequate filling will result in a decreased flow through a decrease in the stroke rate. Thus, the maintenance of an adequate preload is of crucial importance. Direct decreases in the pump flow occur when the preload declines, as a consequence of a decreased venous return secondary to an increased venous capacitance, alterations in the body position that reduce the venous return (lateral decubitus or reverse Trendelenburg position), inadequate administration of intravenous fluids, or uncontrolled surgical bleeding. The preload sensitivity of these devices suggests that the invasive monitoring of RV and pump filling pressures using a central venous, pulmonary artery catheter, or two-dimensional transesophageal echocardiography is necessary. Negative inotropic drugs and factors that can reduce RV output by increasing pulmonary vascular resistance (such as hypoxemia, hypercarbia or acidosis) should be avoided. Progressive increases in the central venous pressure and RV dilatation, combined with simultaneous reductions in LVAD output (or thermodilution-derived cardiac output), are highly suggestive of RV dysfunction and may require an intervention with either positive inotropic drugs (milrinone, dobutamine, or levosimendan) or selective pulmonary vasodilators (inhaled nitric oxide or prostaglandins).

## **Right-sided circulatory failure**

Right-sided circulatory management is the key for successful postoperative care in patients with left ventricular assist device (LVAD). The strategies include the maintenance of chronotropy in the right ventricle (RV) and the decreasing of the

pulmonary vascular resistance. Inhaled nitric oxide may be invaluable in the early management of patients with LVAD, because its vasodilative effect on pulmonary vasculature without the systemic hypotensive effect is more potent than other pulmonary artery vasodilators. Further approaches include the use of a phosphodiesterase inhibitor (most frequently milrinone), nesiritide or levosimendan, usually in combination with a systemic vasoconstrictor. In these patients, vasopressin has an advantage over other alpha-adrenergic agonists, as it possesses minimal vasoconstrictive effects on the pulmonary vasculature. The use of other systemic vasoconstrictors in patients with LVAD is common, as the systemic arterial vasodilation commonly occurs due to various reasons.

### **Hemorrhage**

Postoperative hemorrhage is common in these patients. The preoperative heart dysfunction leads to hepatic congestion and renal dysfunction, both leading to imbalances in the platelet function and the coagulation cascade. An additional exposure of blood to foreign surfaces of cardiopulmonary bypass can exacerbate postoperative bleeding. In the intensive care unit, the prevention of bleeding is provided with warming the patient and with replenishing of platelets and other factors of the coagulation cascade. It is important that in patients, who are transplant candidates, transfusions of platelets and erythrocytes should be given through leukocyte filters to prevent develop antibodies against future donated organs. Fresh frozen plasma and cryoprecipitate do not have a high leukocyte content, and they do not need filtration.

### **Thromboembolism**

Thromboembolism is associated with all current assist systems. The patient with a Novacor or Thoratec device is chronically treated with warfarin, except HeartMate IP/XVE, which appears to have the lowest overall thromboembolic rate and is generally maintained with chronic aspirin therapy alone.

### **Infection**

Device-related infections are the most common cause of morbidity in the chronically supported patients. Driveline and device infections occur in up to 40 % of these patients. The vast majority of these infections may be managed with chronic antibiotic therapy until transplantation. The infection of the blood contacting surfaces of the device (valves or diaphragm) necessitates device change.

## **Cardiac arrest**

In case ventricular tachycardia or ventricular fibrillation occur, it is important – though that device provides given cardiac output – to terminate these rhythm disturbances, primarily due to extreme oxygen consumption. If external defibrillation/cardioversion is used, it is important not to disconnect the percutaneous lead from the system controller and not to stop the pump prior to delivering the shock. The percutaneous lead should only be disconnected in cases where open-heart defibrillation is required. In the event the LVAD stopped operating and blood were stagnant in the pump and conduits for more than a few minutes (depending on the anticoagulation status of the patient), a risk of stroke and/or thromboembolism would exist if the device were restarted. Retrograde flow might occur during pump stoppage. During cardiopulmonary resuscitation (CPR), external chest compressions should be avoided. External chest compressions pose a risk due to the location of the outflow graft on the aorta and the inflow conduit in the left ventricular apex. Dislodgement could lead to fatal hemorrhage. It is necessary to use clinical judgment when deciding whether to perform external chest compressions in these cases.

## **Management of the VAD patients for noncardiac surgery**

These patients can be very ill, and surgery can be contemplated early after VAD implantation. After weeks or months after implantation, patients may safely undergo noncardiac surgical procedures, with attention on several details. Anesthetic induction with sedative–hypnotic drugs, which increase venous capacitance (thiopental, propofol), or rapid administration of other vasoactive drugs, which produce selective dilation of the venous circulation, may produce acute hemodynamic decompensation in the LVAD patient, because the pump blood-flow decreases during these conditions. As a result, hypertension should be specifically avoided, because the emptying of the LVAD is reduced by increases in the arterial pressure. Incomplete LVAD ejection does not only decrease the forward flow, but rather promotes the blood stasis within the device and increases the risk of thrombus formation, even in the presence of systemic anticoagulation. Acute increases in the sympathetic nervous system activity and its consequent effects on the arteriolar tone, produced by laryngoscopy, intubation, or surgical stimulation, represent an important goal in the perioperative management of these patients. These may be avoided by the assurance of adequate anesthetic depth, using volatile anesthetics in combination with an opioid or by the judicious administration of arterial vasodilators to treat increases in the arterial pressure. In the absence of hypertension, most cases of low LVAD flow can be corrected by volume expansion, though RV dysfunction must also be

considered. The management of anticoagulant therapy is another major issue that requires attention in the perioperative care of the LVAD patient. Patients with a Novacor or Thoratec device, chronically treated with warfarin, should be converted to intravenous heparin therapy before elective surgery, similar to patients with a mechanical prosthetic valve. The heparin should be discontinued during the immediate preoperative period and resumed when the risk of postoperative bleeding diminishes. During emergency circumstances, the withdrawal of oral anticoagulants may not be accomplished before surgery, and the transfusion of fresh frozen plasma is required. Patients with HeartMate device are generally maintained with chronic aspirin therapy alone, and excess perioperative bleeding may require platelet transfusion to obtain adequate hemostasis.

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## Sažetak

### **Postoperacijsko liječenje bolesnika s mehaničkom potporom srca u jedinici intenzivnog liječenja**

Nakon ugradnje lijevostrane srčane potpore (LSP), bolesnici se zaprimaju u jedinicu intenzivne medicine. Tijekom ovog razdoblja od nekoliko dana, osnovni cilj poslijeoperacijskog liječenja je stabilizacija bolesnikove hemodinamike. Praćenje kontinuiranog minutnog volumena, tlakova punjenja i sustavne rezistencije je neophodno za ispravno funkcioniranje LSP-a. Uporaba plućnog arterijskog katetera s kontinuiranim mjerenjem minutnog volumena te transezofagijska ehokardiografija su primarni postupci. Za vrijeme rada LSP, praćenje funkcije desne klijetke te rano uočavanje njene disfunkcije od krucijalnog su značaja za dobar ishod bolesnika. Daljnje moguće komplikacije u ovih bolesnika su povećani rizik od krvarenja, kao i od nastanka tromboembolija. Incidencija infekcija u ovih bolesnika je visoka, i kreće se do 40%, osobito infekcije kanila. U slučaju zastoja rada srca, primjenjuju se posebni postupci oživljavanja, koji se razlikuju od uobičajenih algoritama. Na kraju, prikazane su i specifičnosti anesteziološkog postupka u ovih bolesnika ukoliko postoji potreba za nekardijalnom operacijom.

**Ključne riječi:** LVAD; hemodinamika; TEE, LVAD i nekardijalne operacije