Intensive care management of patients with left ventricular assist device

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ABSTRACT

Mechanical circulatory support devices, especially left ventricular assist devices (LVADs) represent an important treatment modality for patients with end-stage heart failure (HF). In a 1-year period (from January to December 2017) in our intensive care unit (ICU) we had a total of 8 patients with LVAD implantation. LVADs are devices with unique physiology which restore tissue circulation by increasing blood supply, nevertheless, they can be challenging to manage and are associated with significant complications.

Keywords: Critical Care, Heart-Assist Devices, Heart Failure, Hemodynamics, Hemodynamic Monitoring, Cardiac surgery, Postoperative Complications

INTRODUCTION

Mechanical circulatory support devices, especially left ventricular assist devices (LVADs) represent an important treatment modality for patients with end-stage heart failure (HF). Considering the shortage of donor organs, improvement in LVAD’s technology and intensive care treatment modalities, the number of patients with LVAD implantation in intensive care units is increasing. Intensive care management of these patients requires an understanding of the principles, indications, and limitations of this unique technology, as well as a multidisciplinary approach (intensivists, cardiac surgeons, anesthesiologists, cardiologists etc.) (1).

Indications for LVAD implantation include: a) bridge to transplantation (BTT), b) bridge to decision (until a determination can be made regarding a patient’s eligibility for cardiac transplantation), c) destination therapy (DT) to support cardiac function for the remainder of a patient’s life and d) bridge to recovery (temporary support for patients whose cardiac function is expected to recover) (2).

Older models of LVADs with pulsatile flow have been replaced with a newer generation of continuous-flow (CF) pumps which are smaller in size, more reliable, durable and subsequently lead to improvements in survival (3). Each LVAD consists of an inflow cannula positioned into the left ventricular (LV) apex, a rotating element that imparts energy to the blood to increase arterial blood flow and pressure, an outflow cannula which directs blood into the ascending aorta and a controller with battery pack.

PATIENTS AND PREOPERATIVE ICU MANAGEMENT

In a 1-year period (from January to December 2017) in our intensive care unit (ICU) we had a total of eight patients with LVAD implantation. Four patients had dilative ischemic cardiomyopathy with LVEF ranging from 15 to 25 % and were planned for LVAD implantation. One patient had dilative cardiomyopathy secondary to congenitally corrected transposition of the great arteries (dextrocardia was also present) who was on the transplant list but had NT (non-transplantable) status. LVAD exchange was planned in three patients due to microthrombosis of the LVAD in one case and infection of driveline in two cases.

All patients planned for LVAD implantation were admitted to our ICU the day before surgery for preoperative assessment and preparation. Arterial cannula for invasive blood pressure monitoring, central venous catheter and pulmonary artery catheter with continuous cardiac output (CCO) and continuous mixed venous saturation (Sv02) monitoring were placed. Thereafter, we recorded basic hemodynamic parameters and their indexed values (IBP, CO, SV, SVR, PVR, PAP, PCWP, LVSW, RVSW, Sv02 and CVP) in all cases. There are indications that preoperative use of levosimendan (calcium sensitiser, inodilator) in patients eligible for LVAD implantation might improve clinical outcome and survival (4,5).

Our protocol in this group of patients included administration of a bolus dose of levosimendan (6 µg/kg i.v.) during 20 minutes and then as a continuous infusion (0.1 µg/kg/h) during 24 hours. In all patients administration of levosimendan was safe and no clinically relevant side effects (significant hypotension, arrhythmias) were observed. Positive effects of levosimendan include improvements in pre-implant hemodynamic performance (higher CI, lowering of PAP and CVP). There is a lack of consensus on the regimen and duration of antibiotic prophylaxis during LVAD implantation. In our ICU antibiotic prophylaxis and potential complications

POSTOPERATIVE ICU MANAGEMENT

In all patients, the third generation of CF LVAD devices was implanted. Three patients received HeartWare
inhind our protocol begins with
thromboplastin time (PTT) of 45-50 sec-
onds (1.2-1.4 x control). After 24-48 hours,
UHF dosing needs to be increased and ti-
trated to a PTT of 50-60 seconds (1.4-1.7 x
control) and after 48–72 hours PTT values
should be 55-65 seconds (1.5-1.8 x con-
trol). Aspirin is initiated on the second or
third postoperative day. Once there is no
evidence of bleeding and the chest tubes
have been removed, warfarin can be start-
ed (overlapping with UHF). UHF can safe-
ly be removed after an acceptable, stable
INR (2.0-3.0) is obtained. Anticoagulation
protocols often differ from the one shown
due to unexpected hemorrhage and/or dif-
f erent sensitivity of individual patients to
administered drugs.
Postoperative complications include, but
are not limited to: bleeding, RV failure, ar-
rhythmias, infections, thrombosis, neuro-
logic events and hemolysis. Postoperative
management of LVAD patients requires a
careful balance between the risks of hem-
orrhage and thrombosis because both procoagulant and anticoagulant pathways
are activated in patients on LVAD support
(9). Bleeding is the most frequent adverse
event in the postoperative period and early
bleeding requiring surgery is seen in 26% of
patients (10,11). Like in other types of
cardiac surgery, one should always try to
recognize cardiac tamponade as it requires
emergent surgical revision. Regular moni-
toring of laboratory parameters including
prothrombin time, partial thromboplastin
time, platelet count and fibrinogen levels
guide the administration of platelets, fresh
frozen plasma, and cryoprecipitate. Factor
VII should be used cautiously in patients
with LVADs given the potential for serious
thromboembolic events, particularly at
higher doses (12).
 Patients with prior cardiac surgery expe-
rience longer cardiopulmonary bypass
(CPB) time and more postoperative bleed-
ing (13). One patient died in the early
postoperative period (eight hours after
surgery) due to a combination of excessive
surgical bleeding and coagulopathy (DIC).
Other forms of bleeding include epistaxis,
GI bleeding (continuous blood flow may
lead to formation of AV malformations) and
intracranial hemorrhage (particularly with
excessively high LVAD flows and
MAP> 90 mmHg). Estimates of the inci-
dence of right-sided HF after placement of
an LVAD vary in literature (5 to 40%, de-
pending on criteria of RV failure) and are
associated with marked deterioration of
survival prospects. Numerous predictors
of post-LVAD RV failure have been identi-
ied like elevated CVP or CVP/PCWP ra-
tio, severe renal dysfunction and ventilator
dependence.14 Specific echocardiographic
measures of RV function have exhibited
poor reproducibility across studies. After
LVAD implantation, RV geometry changes
as the septum shifts to the left with LV un-
loading, causing an increase in RV compli-
ance but a decrease in contractility. Venous
return is increased due to improved CO
from the LVAD, but right ventricular af-
terload may remain high due to increased
PAP.1 Maintaining the septum in its nor-
mal position can be done by carefully moni-
toring volume status, doses of inotropes,
and device settings after echocardiography
assessment. Too high of a pump speed will
shift the septum leftward (causing impair-
ment in RV function), too low of a pump
speed will shift the septum rightward and
cause increased LA pressure which also
impairs RV function.15 In the postopera-
tive period it is prudent to maintain a MAP
>70 mmHg to preserve RV and this often
requires use of one or more vasopressors
(norepinephrine, vasopressin) (2). Factors
which increase PVR such as hypercarbia,
hypoxia, high airway pressures and levels
of PEEP, also need to be avoided. One pa-
tient in our ICU presented with RV failure
after LVAD implantation, presumably due
to septic shock and showed no signs of re-
covery despite high inotropic support, an-
tibiotics and other modalities of intensive
care treatment. Both atrial and ventricular arrhythmias
are common post-LVAD implantation.
Although rapid atrial arrhythmias can be
tolerated initially, loss of AV synchrony
results in reduced ventricular filling and
decompensated RV failure and patients
may therefore require rate or rhythm con-
trol (16). Ventricular arrhythmias can be
triggered by contact between the inflow
cannula and the ventricular septum dur-
ing suction events usually caused by hypo-
volemia, too high of an LVAD speed, RV
failure or small ventricular size (1).
Therefore the speed should be set to avoid ex-
cessive ventricular unloading and volume status optimized if needed.
LVAD patients in cardiac arrest should
be managed with the Advanced Cardiac
Life Support (ACLS) algorithm for car-
diac arrest with a few exceptions. Most
importantly, chest compressions are not
recommended due to potential dislodge-
ment of the device or its outflow cannula
located directly beneath the sternum, in
which case massive hemorrhage can oc-
cur. In this group of patients, infection
(VAD-specific, VAD-related, non-VAD
infections) is the second most common
cause of death after cardiac failure (17).
Our three patients after LVAD implanta-
be various in origin (sign of pump thrombosis, result of too high inlet velocities or can be transfusion related) (20).

**DISCUSSION**

The overall rate of LVAD implantation increases every year, especially the number of LVADs for DT. Generally, all patients planned for LVAD implantation are high risk patients with deteriorated hemodynamic status and lots of comorbidities. Several risk factors for early mortality after LVAD implantation have been identified including advanced age, female gender, obesity, INTERMACS profile 1–2, renal dysfunction, elevated bilirubin and previous cardiac surgery. Of our eight patients, seven were male with an age range from 61–72 years and one was a female and 54 years of age. All of them were INTERMACS 2 profile before surgery and had significant comorbidities (including hypertension, pulmonary hypertension, diabetes mellitus, renal insufficiency etc.).

Our four patients had one previous cardiac surgery (CABG, valve surgery or LVAD implantation) and in one patient who underwent LVAD exchange this was their third cardiac procedure. In our patients, mortality was high due to various causes. One patient died in the operating theatre due to inability to wean from CPB (low cardiac output syndrome and vasoplegemia), three patients died from septic complications (7, 10 and 11 day after surgery) and one patient died from postoperative hemorrhage eight hours after surgery. In the postoperative period LVAD patients require respiratory and hemodynamic support, broad spectrum antibiotics, regular assessment of volume status and heart function, frequent laboratory parameters testing and meticulous attention to bleeding. Once again it should be emphasized that anticoagulation protocols are of great importance but a „one size fits all” protocol does not exist.

To conclude, LVADs are devices with unique a physiology which restores tissue circulation by increasing blood supply, nevertheless, they can be challenging to manage and are associated with significant complications.

**List of abbreviations:**

- LVEF – left ventricular ejection fraction
- IBP – invasive blood pressure
- CO – cardiac output
- SV – stroke volume
- SVR – systemic vascular resistance
- PVR – pulmonary vascular resistance
- PAP – pulmonary arterial pressure
- PCWP – pulmonary capillary wedge pressure
- LVSW – left ventricular stroke work
- RVSW – right ventricular stroke work
- SvO2 – mixed venous saturation
- CVP – central venous pressure
- CI – cardiac index
- PVR – pulmonary vascular resistance
- INR - international normalized ratio
- DIC – disseminated intravascular coagulopathy
- LA – left atrial
- PEEP – peak end expiratory pressure
- INTERMACS - Interagency Registry for Mechanically Assisted Circulatory Support
- CABG - Coronary Artery Bypass Grafting

**REFERENCES**