How to manage physiotherapy and rehabilitation in LVAD patients

Michel Lamotte, Dominique Hansen and Philippe Timmermans provide updated state-of-the-art insights

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With more than 15,000 patients implanted worldwide and a survival rate of 80% at 1 year, and 59% at 5 years, left ventricular assist device (LVAD) implantation has become a valuable and lifesaving therapeutic option in medical management of heart failure patients who are refractory to other kinds of treatment. Some of the patients sent for LVAD implantation are chronic heart failure patients suffering from slow and progressive clinical deterioration. In these, a rehabilitation intervention is frequently proposed already before implantation. It is now evident that there are many clinical benefits of such intervention in this type of population. For patients after implantation, recommendations for exercise training and rehabilitation are established. The aim of this article is to describe these current guidelines in greater detail, and to provide updated state-of-the-art insights and knowledge (Piepoli 2013, Taylor 2014). Another aspect of rehabilitation is that all these cardiac patients (heart failure, LVAD, transplant) are following their training in the same place, they are progressively familiarised with the post LVAD implantation or even the post transplantation program.
Rehabilitation during hospital stay

Physiotherapy after LVAD implantation starts soon after surgery, most often in intensive care unit (ICU). As after all types of cardiac surgery, the first objectives are optimisation of respiratory function and non-specific, but active, mobilization. This means practically: to avoid pulmonary complications (bronchial aspiration, deletion of atelectasis, pleural drainage, and help for cough), to start as soon as possible mobilization (more actively than passively) of lower and upper limbs, to promote sitting position and walking.

When the patient is stabilized, he is transferred to a medium care unit where the physical activity of the patient will be increased, but with sustained emphasis on the care of respiratory function as well. After two days, the patient is usually able to walk alone in his room. The main goal of physiotherapy is to achieve patient autonomy: walk, bicycle and muscular strengthening of lower limbs. Those exercises are, of course, mainly done outside of the room and are a good way also to teach the patient how to handle an alarm and batteries changes. At the end of the hospitalization, the patients must be able to walk alone and to climb the stairs.

Ambulatory rehabilitation

During the hospital stay, patients are always strongly invited to follow the ambulatory rehabilitation program: 3 to 5 times per week, with a duration between 45 and 90 minutes. Of course, this training is more intensive as opposed to the in-hospital rehabilitation, but its feasibility is well recognised (Compostella 2015, Marko 2014). The positive impact on the physical recovery (Haft 2007, Laoutaris 2011, Pruijsten 2012, Rogers 2010) and on the psychological aspect (Karapolat 2013, Kugler 2012) are demonstrated. This will help the patient to restore step by step his place in the family and in the society.
How to do it?

No official guidelines or even clear recommendations exist to determine precise training modalities for LVAD patients. However, the EXPERT (Exercise Prescription in Everyday practice and Rehabilitation Training) flowchart - a digital tool that assists rehabilitation experts in the determination of exercise training modalities for patients with cardiovascular disease or risk - Developed by the University of Hasselt in collaboration with the Cardiac Rehabilitation Section of the European Association for Cardiovascular Prevention and Rehabilitation (EACPR), will be published in 2016, and will address LVAD patients.

It seemed appropriate to build the program on the established recommendations for heart failure since many problems are common to both populations. Therefore, based on this literature, we decided to take care of two aspects of the rehabilitation:

**Dynamic or Endurance exercise training**: Endurance exercise training induces an improvement of the aerobic metabolism, of the cardiovascular autonomic regulation, on the peripheral perfusion, but also on cardiovascular risk (blood pressure, blood lipid profile, glycaemic control), inflammation and body composition (mainly adipose tissue mass). In this type of patient, such changes are instrumental to improvements in quality of life, although the exact prognostic impact is not yet established. However, another very interesting benefit of rehabilitation in congestive heart failure (CHF) patients is a decrease in hospital (re)admissions.

**Muscle strength training**: Due to the usual previous physical inactivity, this part of the rehabilitation programme is mandatory in order to increase muscle strength and/or muscle endurance, which has a significant functional impact. Due to the increased blood flow, there is an increased mitochondrial ATP production rate, a better oxidative capacity and a relative increase of flow distribution in the area of type I fibres. Other mechanisms like : induce local anaerobic metabolic adaptations, to force the muscle to activate mTOR, activate satellite cells, increase type 2 b muscle fiber size, are proposed to induce muscle hypertrophy and increase muscle strength. Again with those physiological benefits, we will obtain an increased quality of life and a potential supplementary increased of VO² peak demonstrated in some studies. Based on the physiological understanding of the Fick equation: \( \text{VO}^2 = Q \times (\text{Ca O}^2 - \text{Cv O}^2) \), we know that we have to work on the flow (Left ventricular assist Device) and the muscular extraction of O² to increase the peak VO². It is the reason why rehabilitation programs must propose a **combined training**.
How to structure the exercise training?

After the Heartmate II trial in 2009, current standard in VAD therapy is to use a continuous rather than pulsatile flow device (Slaughter 2009). The absence of pulse and the measurement of a mean arterial pressure (not easy) has created the necessity to design the training on the maximal workload obtained during cardio-pulmonary exercise testing (CPET). The endurance exercise training is based on a CPET practiced on bicycle, treadmill or other similar ergometer. The feasibility of a maximal test is well demonstrated in the literature, proved by the respiratory exchange ratio (RER) (Dimopoulos 2011, de Jonge 2001, Haft 2007, Jakovlejic 2010& 2011, Laoutaris 2011, Marko 2014, Martina 2013, Pruijsten 2012). It is mandatory to obtain this maximal test in order to optimize the structure of the training and also to obtain a unique scale to compare results (intra and inter studies). When this CPET is maximal with a respiratory exchange ratio >1.15 and without anomaly, the workload for the training on a bicycle will be fixed to 70-80% of the Watts max. Some authors used the target of exercise around 60-70% of the VO²max (Karapolat 2013) or 50% of the VO² reserve (Hayes 2012). Another way to follow this endurance training is the Borg scale: level 12-14 (somewhat hard) on a scale of 20, proposed in some studies (Karapolat 2013, Laoutaris 2011, Marko 2014). During the exercise programme, exercise intensity is also adapted according subjective sensations.

The “interval training” has not shown supplemental benefit in term of VO² peak increase for these types of patients. However, the supplemental improvements obtained in patients suffering from cardiac failure, via “the peripheral pathway” and the higher workload developed with this type of training, give us the feeling that this kind of training should be proposed as a complementary modality. For the same reason, training with work period above the first ventilatory threshold seems to be pertinent and feasible (Hayes 2012, Compostella 2015).

As mentioned before, endurance exercise training must be followed by strength training within the same exercise bout: the principal muscular groups (arms, legs, back, abdominal) must be trained with specific tools (Hayes 2012, Karapolat 2013, Kerrigan 2013, Marko 2014). Those specific exercises address qualitative and quantitative muscular changes which are met in the heart failure patients, and increased by a prolonged bedrest (Harrington 1997, Clark 2006). Usual modalities proposed 2 to 3 sets of 10 to 15 repetitions with an intensity comprised between 50 and 75 % of 1-RM (Hayes 2012, Karapolat 2013, Kerrigan 2013, Laoutaris 2011, Marko 2014).
Other forms of strength training are emerging (in other patient populations) such as muscular electrostimulation. This technology is however limited to few specific muscle groups, and is more about addressing non-compliant patients or patients not able to exert a voluntary muscular contraction.

Only one study proposes a training of the respiratory muscles (Laoutaris 2013).

As in the general heart failure population, anaemia and iron deficiency need to be corrected in order to improve exercise capacity. At the moment, there is no evidence to increase VAD speed during exercise to improve VO\textsuperscript{2} max with the currently available devices. This is still a matter of ongoing clinical research, and may change with the upcoming new generation of VAD devices.

On the contrary, in multiple studies, as for heart failure patients, there is a major interest of a multidisciplinary team intervention: psychologists, nutritionists ..., in close collaboration with the LVAD team (Compostella 2015, Hayes 2012, Karapolat 2013, Kugler 2012, Rogers 2010). Patients with end stage HF on VAD therapy usually already have a prolonged medical history of chronic illness with multiple cardiac interventions. After VAD implantation and successful rehabilitation, they are directly responsible for the durability of their live saving device by maintaining strict anticoagulation targets, fluid challenging, monitoring and managing battery power while applying hygienic measures to prevent percutaneous driveline infections. A multidisciplinary team approach is necessary to support VAD patients in tackling these challenges and care coordination.

**Our experience at CUB Erasme Hospital – Brussels Belgium**

We execute the first CPET at 6 weeks after LVAD implantation, at 3 months, 6 months and one year in order to follow the functional capacity of the LVAD patient and also to re-adapt the training program. 33 patients did a CPET at 6 months post-implantation. In this group, peak workload was 76 +/- 34 watts, which corresponds to 45 +/- 15 % of predicted values (PV). Peak VO\textsubscript{2} was 53 +/- 17 % of PV, i.e. 15.6 +/- 6.0 ml/kg/min. Ve/VCO\textsubscript{2} slope was 38.7 +/- 8.2 with a peak RER of 1.21 +/- 0.10. They are great discrepancy in exercise tolerance within our patients (between 23 and 98 % of peakVO\textsubscript{2} PV). Those discrepancies are reported in other series (Haft 2007, Hayes 2012, Kugler 2012, Laoutaris 2011, Marko 2014).
Fourteen patients out of 33 took part to an outpatient rehabilitation program. The 19 left were not rehabilitated for reasons other than medical. For an equivalent RER, exercise capacity of rehabilitated patients is clearly higher (100 W versus 58 ; 18,5 ml/Kg.min of VO² versus 13,4; Ve/VCO2 slope 35,9 versus 40,7). As LVAD device parameters (flow, power and speed) were similar for the two groups, the differences in effort capacity can be partially explained by the peripheral compartment.

In order to show post-implantation exercise capacity evolution (either spontaneous or following rehabilitation), we confronted results for the 2 groups of patients evaluated at 6 weeks and 6 months post-implantation. Rehabilitation group increase the maximal workload by 64% versus 27% for the non-rehabilitation group; peak VO² (ml/Kg.min) increases by 32% in the first group, whereas just a slight increase of 2% can be observed in the second one. Ve/VCO2 slope shows a 2,7 points decrease in the rehabilitation group, while in contrast it remains stable for the second group. This underlines the importance and effectiveness of a structured rehabilitation after LVAD implantation.

**Discussion**

In our LVAD patients, the improvement of maximal exercise capacity may be explained by the increased flow (increase of the pre load due to the venous return and decrease of the after load due to the peripheral vasodilatation) and by an increase of the O² peripheral extraction. As in heart failure patients, the improvement of VO² values is not concomitant with an improvement of the hemodynamic measurements: this confirms the need of a training oriented to the peripheral muscles (Hambrechts 2015, Maybaum 2007). With continuous flow pumps, peak VO² values observed in some patients (our experience and in the literature) can not be totally explained by the flow of the pump (fixed runs per minute). So only the participation of the “native” heart due to the inotropic effect of exercise may explain such a performance: the pump and the native heart is working in parallel (Andersen 2010, Brassard 2011, Hayes 2012, Hu 2013, Jaski 1999, Martina 2013, Maybaum 2007, Simon 2005). It is common to observe for those VAD patients the absence of opening of the aortic valve at rest and the restoration of a pulse and a pulsatile flow during exercise. Those adaptations need to be investigated in more detail.
Conclusion

Specific clinical guidelines for the prescription of exercise training intervention for LVAD recipients remain lacking in current literature. However, evidence is accumulating that the prescription of endurance and strength training exercises leads to many clinically relevant benefits. However, the impact of the manipulation of certain exercises modalities, as well as the inclusion of newer forms of exercise training, remains to be studied in greater detail in LVAD patients. Despite these uncertainties, some clinical guidelines for the prescription of exercise training in LVAD recipients are provided in this article.

Bibliography


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