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Gently handling the acutely failing right ventricle . . . at last!

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A minimally invasive approach for temporary mechanical circulatory support (MCS) implantation has been a 'dream' for many operators, care-givers and, especially, patients. Indeed, MCS implant has been associated for a long time with invasive approaches, which were required to position the drainage and return cannulas. These approaches often involve invasive surgery to gain accesses to the intrathoracic structures and main vessels, turning MCS implantation into a high-risk procedure. Moreover, such invasive approaches are burdened with further potential complications such as infection of the wound, bleeding from the implantation site, difficult nursing management and significant limitation to patient's mobility.

Patients diagnosed with acute right ventricular failure (aRVF) after a left ventricular assist device (LVAD) implantation often experience the above-mentioned scenario. Indeed, the management of early aRVF after LVAD implantation may require the use of a dedicated temporary right ventricular assist device (RVAD) and, sometimes, even a durable RVAD [1]. Peripheral veno-arterial extracorporeal membrane oxygenation has been applied as bridge to recovery for the post-LVAD failing right ventricle (RV). Nevertheless, it is characterized by several drawbacks such as the decrease of LVAD preload due to RV unloading, the increase of LVAD afterload with risk of reduced forward blood flow and protracted aortic valve closure, potentially leading to thrombotic events. Furthermore, a complete RV and pulmonary bypass might lead to a marked reduction of the blood flow through the pulmonary vascular system, which is associated to vascular and lung reperfusion damage once the normal circulation is restored [2].

It goes without saying, therefore, that managing post-LVAD aRVF requires a peculiar decision-making process and the application of alternative and innovative solutions. An increased awareness about post-LVAD aRVF, the appraisal of its actual incidence and a higher attention to a timely diagnosis and management have led to a broader use of dedicated temporary MCS able to support the failing RV through less invasive techniques. The major breakthrough in this setting has certainly been represented by the development of a percutaneous approach to the pulmonary artery (PA) [3]. Indeed, reaching the PA with the percutaneous implantation of a single-lumen (Biomedicus, Medtronic, Inc., Minneapolis) or double-lumen (ProtekDuo®, TandemLife) cannula [4], as well as a the availability of a dedicated percutaneous RVAD (Impella RP, Abiomed, Danvers, MA, USA), has introduced new concepts and options in the management of aRVF [5, 6].

The paper by Natanov *et al.* [7] illustrates a limited, yet significant single-center experience with a percutaneous-based access for the treatment of aRVF after LVAD implantation. In 14 patients recruited during a 62-month period, Natanov *et al.* [7] investigated the feasibility of a trans-jugular approach for the establishment of a veno-pulmonary MCS (in some patients with oxygenator, reproducing an OxyRVAD configuration) as support of the failing RV during or after LVAD implantation [7]. All patients received a 15-F single-lumen return cannula (BioMedicus, Medtronic, Minneapolis, MN, USA) in the PA, implanted with the use of a guidewire previously inserted and positioned with a Swan-Ganz catheter into the PA. The draining canula was always implanted with a Seldinger technique into the femoral vein. Among the 14 patients, 12 survived and demonstrated favourable outcomes in terms of RV recovery ($n = 7$), implantation of a durable RVAD ($n = 4$) or heart transplantation ($n = 1$).

Rather than the novelty of a specific trans-jugular percutaneous technique, already described in several publications [2–5], Natanov *et al.* [7] developed the concept of a minimally invasive PA approach simultaneous to LVAD implantation. The possibility to accomplish a minimally invasive RV support in such circumstances is certainly an additional step towards an enhanced LVAD patient management. The reduced impact of this technique compared to the traditional temporary RVADs allows for a prophylactic and timely support of the failing RV during and after LVAD implantation [8].

Interestingly, as 7 patients showed RV recovery, 6 of them (85.7%) underwent implantation of the temporary RVAD simultaneously to LVAD surgery. This successful synchronous approach of LVAD implantation combined with an RV support

device emphasizes the need for adequate timing in the management of post-LVAD aRVF. Indeed, as identified by Harjola *et al.* [9] in the consensus paper from the European Society of Cardiology about general RVF management or also in the experience of Kapur *et al.* [10] about medically refractory RVF, the timing of RVF management is the key to success. A proper planning of the strategy for RVF prevention and treatment should consider also the appropriateness of the logistic environment. As performing a minimally invasive PA cannulation requires the presence of fluoroscopy, the use of a hybrid operating room and the presence of a multidisciplinary team may be required to offer an adequate, timely and less invasive approach to these patients.

For decades, aRVF has represented a neglected and troublesome complication, with challenging management and dismal results, particularly after LVAD implantation. Nowadays, it has become a well-manageable adverse event, with several minimally invasive and percutaneous solutions to overcome it. Obviously, care must be taken since life-threatening complications may also occur while percutaneously reaching the PA, but adequate knowledge and training may turn this approach into a doable procedure in the overall RVF scenario, but particularly in LVAD patients.

Further research in this setting is ongoing, and consistent information will soon be available to ultimately confirm the efficacy and most likely superiority of percutaneous approaches as compared to more traditional and invasive ones. Percutaneous access to dedicated and isolated RV dysfunction is now a reality . . . at last!

Conflict of interest: Roberto Lorusso is a consultant for Medtronic, Getinge and LivaNova, and an Advisory Board Member of Eurosets: all honoraria are paid to the University for research support.

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