Left ventricle unloading in extracorporeal life support

V-A ECLS, in both peripheral or central configurations, may represent the final choice for patients in severe CS or refractory CA. Currently, despite ECLS, survival in such advanced and severe conditions remains poor. The efficacy of V-A ECLS is therefore variable, since the outcome can be influenced by numerous factors, such as its shortcomings. Among them, the effect of retrograde flow in the aorta towards the left ventricle is one of the most important concern. This unwanted effect may impact LV performance and jeopardize its recovery.

Chapter 1. This chapter presents a general extensive introduction on ECLS and provides the scientific background. The LV hemodynamics and workload is fully treated, guiding the readers towards a better understanding, not only the unloading “dilemma”, but also the current work aims.

Chapter 2. A comprehensive overview investigating the different LV venting techniques and results currently available is reported. A systematic literature search, including 207 articles published between 1993 and 2016, reveals a significant gap of knowledge and very heterogeneous indications. On one hand, despite the all the controversies, IABP is widely adopted as unloading tool. On the other hand, percutaneous approaches and sophisticated unloading devices seem to become increasingly used options.

Chapter 3. Protracted aortic valve closure is identified as an early marker of increased afterload which may complicate peripheral V-A ECLS. Among 184 adult patients who were treated with peripheral V-A ECLS at Medical University Center Maastricht Hospital between 2007 and 2018, only 10 patients showed protracted aortic valve closure and inefficient LV unloading. Although in a limited number of patients, IABP is able to overcome such a hemodynamic impairment in 8 out of 10 cases, unfortunately, without improving the weaning rate and survival. Additionally, a novel definition of LV overloading is advanced, recognizing a central role the echocardiography.

Chapter 4. A dedicated CS model includes 12 swine supported with V-A ECLS and randomizes to Impella or pulmonary artery drainage. A full evaluation of LV unloading and end- organ perfusion is performed through the pulmonary artery catheter and LV pressure/ volume analysis. The results clearly shows that the transaortic suction device and pulmonary artery drainage provides effective LV unloading during V-A ECLS and maintains adequate end-organ perfusion. Impella is able to achieve a more consistent pressure-volume area reduction, by almost 34.7%, compared to 9.7% with PA cannula. Consequently, Impella provides a greater LV unloading effect and reduces more effectively the total LV stroke work.

Chapter 5. Based on the promising results obtained in our previous CS model, this chapter provides an extensive treatise on the addition of Impella

to V-A ECLS. This strategy, besides the presented pre-clinical data, has been consistently supported by retrospective propensity-matched studies, case series, and meta-analyses. The pathophysiologic background is related to the mitigation of the LV distension and pressure overload as a direct effect of the retrograde flow into the aorta. A deep report of these mechanisms is proposed in addition to an introduction of some clues regarding the best clinical practice and device management.

Chapter 6. This chapter allows to quantify and understand in depth the unloading effect of percutaneous balloon atrial septostomy in profound CS supported with V-A ECLS. CS is induced by a coronary artery balloon occlusion in eleven swine. Immediately after balloon atrial septostomy while on V-A ECLS, left ventricular work drops by about 22%, as a consequence of reduced preload, afterload and stroke volume. Furthermore, our experimental data identifies the end-systolic pressure increase as the strongest determinant of mechanical work increase. Therefore, besides unloading, careful blood pressure control plays a key role in cardiogenic shock management with V- A ECLS.

Chapter 7. Pediatric patients affected by congenital heart disease represent a very interesting study population. On one hand, scanty data are currently available in this cohort of study. On the other end, the common absence of further comorbidities, might better test the impact of LV venting on the major outcomes. The clinical outcomes of 90 pediatric patients affected by different congenital heart disease and supported with V-A ECLS, mainly in post cardiotomy setting, were retrospectively reviewed. The presence of active LV unloading strategy, mostly through surgical atrial septostomy, increased by almost three times the in-hospital survival. On the contrary, cardio-pulmonary resuscitation decreased the related survival.

Chapter 8. This chapter has the primary aim to summarize the most recent evidence on LV unloading. Our experimental findings in association with the available clinical experience are condensed and this piece of work represents nowadays our strategy in patients supported with V-A ECLS. The LV overload definition is, therefore, reproposed and significantly improved. The role of counter pulsation is better clarified, supported by the discovered effectiveness in reversing early signs of overload. Furthermore, the choice of more advanced and aggressive LV unloading strategy is, finally, based on solid experimental findings. The overall result represents our current policy on LV unloading during V-A ECLS which is summarized in a detailed algorithm.