Pressure-strain loops unveil hemodynamics behind mechanical circulatory support systems

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Background: Mechanical circulatory support (MCS) systems are increasingly employed in critical hemodynamic states, such as in cardiogenic shock and end-stage heart failure. A thorough understanding of the complex interactions occurring between heart, vasculature and device is essential to optimize patient’s management.

Purpose: This study aimed to explore the hemodynamic profile of patients under MCS using a non-invasive method based on pressure-strain analysis.

Methods: Consecutive patients admitted to the cardiological intensive care unit (CICU) from August 2021 to January 2022 undergoing different MCS systems positioning/implantation were retrospectively reviewed. Patients without a useful echocardiographic exam and/or arterial blood pressure invasive measurement at the time of echocardiography were excluded. Myocardial work analysis by Speckle Tracking Echocardiography (STE) was performed in these patients.

Results: 3 patients with intra-aortic balloon pump (IABP), 2 patients with durable left ventricular assist device (dLVAD), 2 patients with temporary left ventricle (LV)-to-aortic pump, 1 patient with extracorporeal membrane oxygenation (ECMO) and 1 patient with ECMO and IABP were included. The use of IABP shifted the pressure-strain curve rightward and downward. Global work index (GWI) and global wasted work (GWW) decreased after IABP positioning, whereas global work efficiency (GWE) increased. The use of continuous-flow LV-to-aortic pumps, whether temporary or long-term (dLVAD), induced a significant change in the pressure-strain loop, with a shift towards a triangular shape. ECMO positioning alone resulted in a narrowing of the pressure-strain loop, with a decrease in GWI and GWE and an increase in GWW and mean arterial pressure. The combined use of IABP with ECMO widened the pressure-strain loop and improved GWI and GWE.

Conclusions: Pressure-strain loops unveil hemodynamic variations induced by mechanical circulatory support systems. Thus, myocardial work could be used to monitor ventricular-arterial-device coupling in such patients and therefore guide tailored management.

Figure 1. A) Red curve represents PS loop previously to IABP support, yellow curve represents PS loop during IABP support. B) Red curve represents PS loop previously to ECMO support, yellow curve represents PS loop during ECMO support. C) Red curve represents PS loop previously to ECMO support, yellow curve represents PS loop during ECMO and IABP support, green curve represents PS loop after ECMO and IABP removal. D) PS loop during temporaneous LV-to-aortic pump support. E) PS curve during dLVAD support. PS = pressure-strain; IABP = intra-aortic balloon pump; ECMO = extracorporeal membrane oxygenation; LV = left ventricle; dLVAD = durable left ventricular assist device.