LV Unloading using Impella CP Improves LA Pressure, Function, and Stiffness

Shin Watanabe, MD, Kenneth Fish, PhD, Lauren Leonardson, LVT, Roger J. Hajjar, MD, Kiyotake Ishikawa, MD,

Icahn School of Medicine at Mount Sinai, New York, U.S.A

ABSTRACT

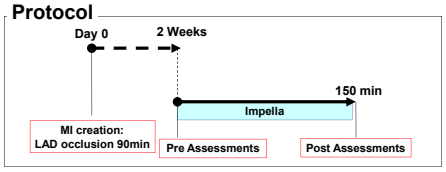
Background: LV (left ventricle) to aorta percutaneous left ventricular assist device (pLVAD), Impella, supports systemic hemodynamics by increasing cardiac output and unloading LV. However the impact of Impella support on upstream of LV remains unclear.

Hypothesis: Unloading the LV with an Impella CP improves trans-mitral pressure gradient, leading to a reduction of LA pressure and improved LA function and stiffness.

Results: Two-weeks after the MI, the animals presented with impaired LVEF (69.7±10.5 to 38.6±7.0 %, P=0.03) and a dilated LV (LV end-systolic volume: 24.55±10.7 to 65.3±16.3 mL, P=0.04) without significant mitral regurgitation. LV unloading with maximal pump support (P8) resulted in an increase in total cardiac output (2.80±0.18 to 3.27±0.22 l/min, P=0.03) and reduced LV end-diastolic pressure (27.5±10.1 to 17.9±4.5 mmHg, P=0.06). These changes were accompanied by a significant reduction in mean LA pressure (17.3±2.6 to 10.8±2.1 mmHg, P=0.001). LA volumes assessed by 3-dimensional echocardiography were also reduced (LA Maximal volume: 40.3±4.6 to 29.0±2.3 ml, P=0.006, LA Minimal volume: 20.3±2.7 to 15.0±2.3 ml, P=0.002). While the total LAEF was not altered from the baseline (49.3±6.4 to 48.5±6.5%, P=0.85), passive LAEF was significantly increased (17.7±1.9 to 39.4±5.6 %, P=0.008), suggesting an improved trans-mitral suction effect. Additionally, LA stiffness assessed by pressure-volume coordinates was improved with Impella support (1.41±0.52 to 0.30±0.16 mmHg/ml, P=0.03).

METHODS

HF is induced by percutaneously occluding the proximal LAD for 90 minutes in Yorkshire pigs (n=4, 40-50 Kg). Two-weeks after the MI, animals underwent LV unloading with an Impella CP for 150 minutes. LA pressure was directly measured by a trans-septal approach and LA volumes were assessed by 3-dimensional echocardiography. LA stiffness was approximated as the slope of minimal and maximal LA pressure–volume coordinates as described previously (***Circ Heart Fail*. 2015;8:295-303.**).



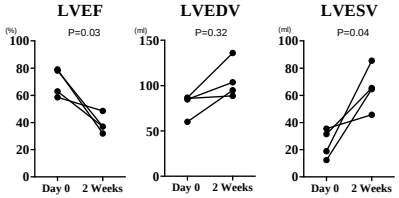


Figure 1. LV ejection fraction, LV end-diastolic volume and LV end-systolic volume at 2 weeks (before LV unloading)

RESULTS

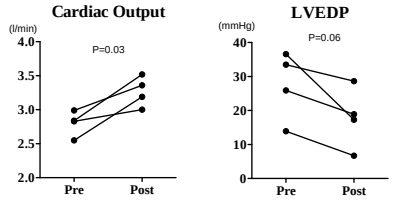


Figure 2. LV unloading with maximal pump support (P8) resulted in an increase in total cardiac output and reduced LV end-diastolic pressure.

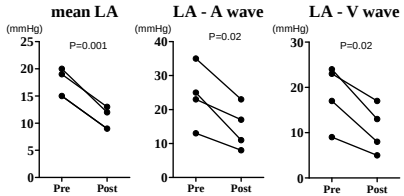


Figure 3. LV unloading reduced left atrial (LA) pressure (mean LA, A wave and V wave).

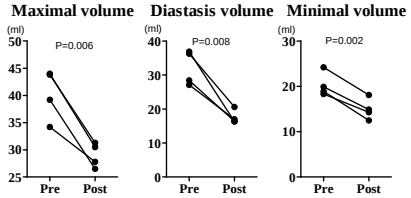
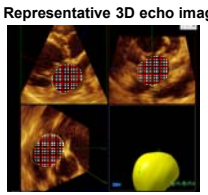


Figure 4. LV unloading reduced Left atrial (LA) volume (maximal, diastasis and minimal volume).



$$\text{Total LA EF} = \frac{V\,max - V\,min}{V\,max}$$

$$\text{Passive LA EF} = \frac{V\,max - V\,diastasis}{V\,max}$$

Equations used for LA functional characterization. EF indicates ejection fraction

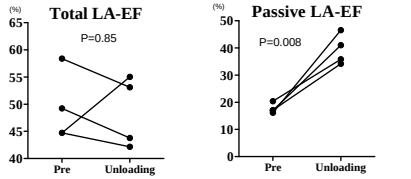


Figure 5. While the total LAEF was not altered from the baseline, passive LAEF was significantly increased.

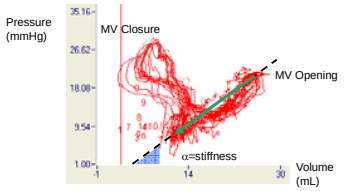


Figure 6. Representative LA pressure–volume relations in pig with HF. The linear regression line of the diastolic part of the pressure–volume relation, corresponding to the period between the nadir of the x wave (Arrow head) and the peak of the V wave (Arrow) of the LA pressure was used as an estimate of LA stiffness. These points were determined from LA pressure curve and 3D echocardiography.

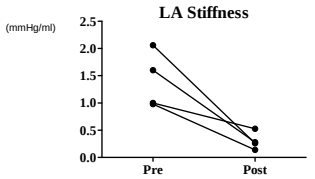
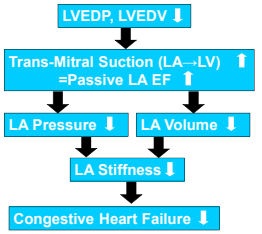


Figure 7. LA stiffness assessed by pressure-volume coordinates was improved with Impella support

CONCLUSIONS

LV unloading using an Impella CP improves passive LA function and reduces mean LA pressure in a recent MI setting. Along with improved LA stiffness, these data implicate a beneficial impact of LV unloading on relieving HF symptoms.



REFERENCES

1. Melenovsky V, Hwang SJ, Redfield MM, Zakeri R, Lin G, Borlaug BA. Left atrial remodeling and function in advanced heart failure with preserved or reduced ejection fraction. *Circ Heart Fail.* 2015 Mar;8(2):295-303.
2. Kawasaki M, Tanaka R, Ono K, Minatoguchi S, Watanabe T, Iwama M, Hirose T, Arai M, Noda T, Watanabe S, Zile MR, Minatoguchi S. A novel ultrasound predictor of pulmonary capillary wedge pressure assessed by the combination of left atrial volume and function: A speckle tracking echocardiography study. *J Cardiol.* 2015 Sep;66(3):253-62.
3. Barbier P, Solomon SB, Schiller NB, Glantz SA. Left atrial relaxation and left ventricular systolic function determine left atrial reservoir function. *Circulation.* 1999 Jul 27;100(4):427-36.
4. Dernellis JM, Stefanadis CI, Zacharoulis AA, Toutouzas PK. Left atrial mechanical adaptation to long-standing hemodynamic loads based on pressure-volume relations. *Am J Cardiol.* 1998 May 1;81(9):1138-43.