

LV Unloading using an Impella CP Reduces Wall Stress and Improves Coronary Flow and Perfusion in Infarcted Myocardium

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Background

LV unloading may improve coronary perfusion by increasing cardiac output and reducing LV wall stress. Whether sustained LV unloading improves myocardial perfusion in a post-MI setting remains uncertain.

Hypothesis

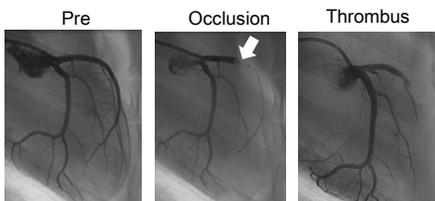
Unloading a post-MI LV with an Impella CP increases coronary flow and myocardial perfusion by reducing LV wall stress and increasing cardiac output.

Methods

To mimic patients who need LV support, large anterior transmural MI was induced by occluding the proximal LAD for 90 minutes in **Yorkshire pigs (n=5, 40-50 Kg)** followed by a thrombus injection through the balloon lumen to induce total occlusion of the LAD. Two-weeks after the MI, animals underwent LV unloading with an Impella CP for 120 minutes. Epicardial coronary flow was assessed by coronary flow wire before, 5 minutes and 120 minutes after LV unloading. Myocardial perfusion was assessed using fluorescent microspheres before and 120 minutes after LV unloading.

Model

Proximal left anterior descending artery was percutaneously occluded for 90 min followed by thrombus injection through the balloon lumen.



Protocol



CF: Coronary flow measurement using Flowire (Volcano)
MP: Myocardial perfusion assessed by fluorescent microspheres
Echo: Echocardiographic volume assessment

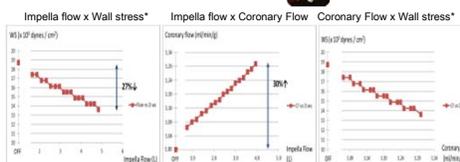
Results

Coronary angiograms revealed TIMI 2 flow in 4 animals, and TIMI 3 flow in one animal. LV unloading with maximal pump support (P8) for two hours resulted in an increase in total cardiac output (3.08 to 3.93 l/min, P=0.07). Impella support significantly reduced end-diastolic volume (109±17 to 85±12 mL, P=0.02) and end-diastolic pressure (29.3±5.6 to 19.2±6.9 mmHg) resulting in a significant decrease in LV end-diastolic wall stress (infarct: 34.4±5.5 to 20.2±5.2 kdynes/cm², P=0.03; remote: 32.4±8.6 to 19.3±6.0 kdynes/cm², P=0.03). Coronary flow increased acutely (LAD: 6.7±1.8 to 10.2±1.5 cm/s, P=0.03, LCx: 8.4±2.7 to 10.4±3.6 cm/s, P=0.31) and remained elevated at 120 minutes (LAD: 9.8±1.3 cm/s, P=0.058, LCx: 12.4±4.2 cm/s, P=0.058). Compared to baseline, myocardial perfusion as measured by fluorescent microspheres within the infarct zone was significantly increased (87±67%, P=0.02), while perfusion of the remote non-ischemic myocardium was similar compared to the baseline (-2±15%, P=0.89), likely due to auto-regulation in the non-injured myocardium.

Simulation using Harvi

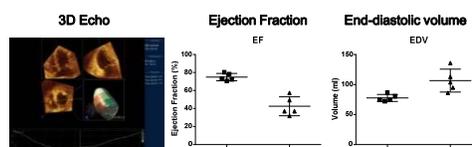


*End-diastolic wall stress



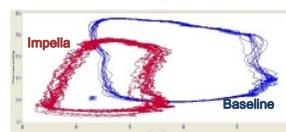
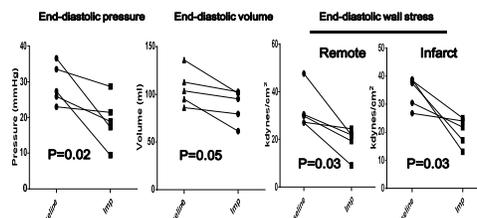
Settings: Chronic heart failure, EF=19%, EDV=230ml, EDP=30mmHg, CO=4l/min, LM stenosis=0%, LV mass=205g

Impaired cardiac function 2 weeks after MI induction



LV unloading using Impella CP reduces LV wall stress

Two hours after Impella support (P8), both end-diastolic pressure (EDP) and end-diastolic volume (EDV) decreased in all pigs, resulting in significant reduction of end-diastolic wall stress.



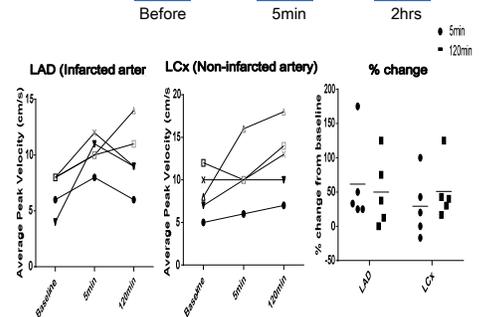
*WS = 0.334 EDP(LVIDd)/WT(1 WT/LVIDd)

Representative pressure-volume loops before and during Impella support

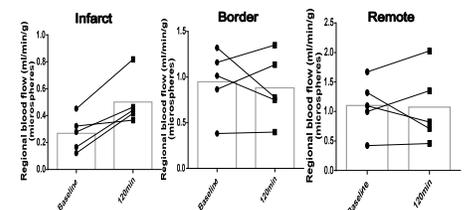
Increased coronary flow assessed by flowire

Coronary flow was measured using flowire before Impella, 5 min, & 2 hrs after Impella initiation.

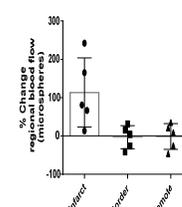
Order: LAD-LCx - LCx-LAD - LAD-LCx



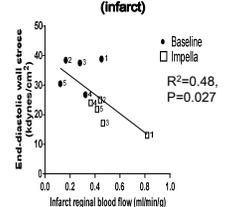
Increased myocardial perfusion in the infarct & its relation to end-diastolic wall stress



Change in myocardial perfusion



Wall stress vs Myocardial perfusion (infarct)



Summary

- Impella support increased coronary flow in both infarcted and non-infarcted artery.
- Myocardial perfusion was improved in only the infarcted area.
- There was a linear relationship between myocardial perfusion in the infarct and the end-diastolic wall stress.

Conclusion

Sustained LV unloading using an Impella CP increases coronary flow and perfusion of the infarcted myocardium for at least 2 hours.