

Significance of Aortic Valve Insufficiency with Left Ventricular Assist Device: Duration and Regurgitant Flow in a Mock Loop

Yuki Tanaka, MD^{#1}, Vi Vu, MS^{#2}, Irene Fischer, MPH^{#1}, Tomohiro Nakajima, MD^{#1}, PhD, Yuko Soyama, MD^{#3}
Karen May-Newman, PhD^{#2}, Akinobu Itoh, MD, PhD^{#1}

#1 Division of Cardiothoracic Surgery, Department of Surgery, Washington University School of Medicine, Saint Louis, MO, USA
#2 Division of Biomedical Engineering, San Diego State University, San Diego, CA, USA
#3 Cardiovascular division, Washington University School of Medicine, Saint Louis, MO, USA

Introduction

The aortic valve insufficiency (AI) grade for patients with left ventricular assist device (LVAD) has been assessed using the traditional method for no LVAD patients, such as effective regurgitant orifice area (EROA) or regurgitant jet.¹ In patients with LVAD, suction to left ventricle may lead to more AI regurgitant volume during a much longer period in a cardiac cycle compared to no LVAD patients with same AI grade based on EROA and regurgitant jet, which possibly result in underestimation of AI severity in LVAD patients compared to no LVAD patients with same AI grade. The purpose of this mock loop study was to investigate the difference of AI duration and regurgitant volume in the same AI grade between **Off** and **On** LVAD condition.

Methods

- All measurements were performed using San Diego State University mock loop system (Figure 1) with a dilated silicone LV model attached to a HeartMate II continuous flow LVAD (Abbott laboratory, Abbott Park, IL, USA).²
- The Off LVAD baseline condition and the On LVAD condition with same systemic resistance were established, followed by testing at three AI severity level.

Off LVAD baseline setting

Ejection fraction = 17%, Heart rate = 62 bpm, Blood pressure = 65 mmHg

On LVAD setting (8,800 rpm)

Ejection fraction = 17%, Heart rate = 62 bpm, Blood pressure = 90 mmHg

- AI severity level was defined as mild, moderate and severe based on EROA, regurgitant fraction and vena contracta.³ AI conditions were created with small 3-D printed stents.

	Mild	Moderate	Severe
EROA, mm ²	3	10	15
Regurgitant fraction, %	23	38	69

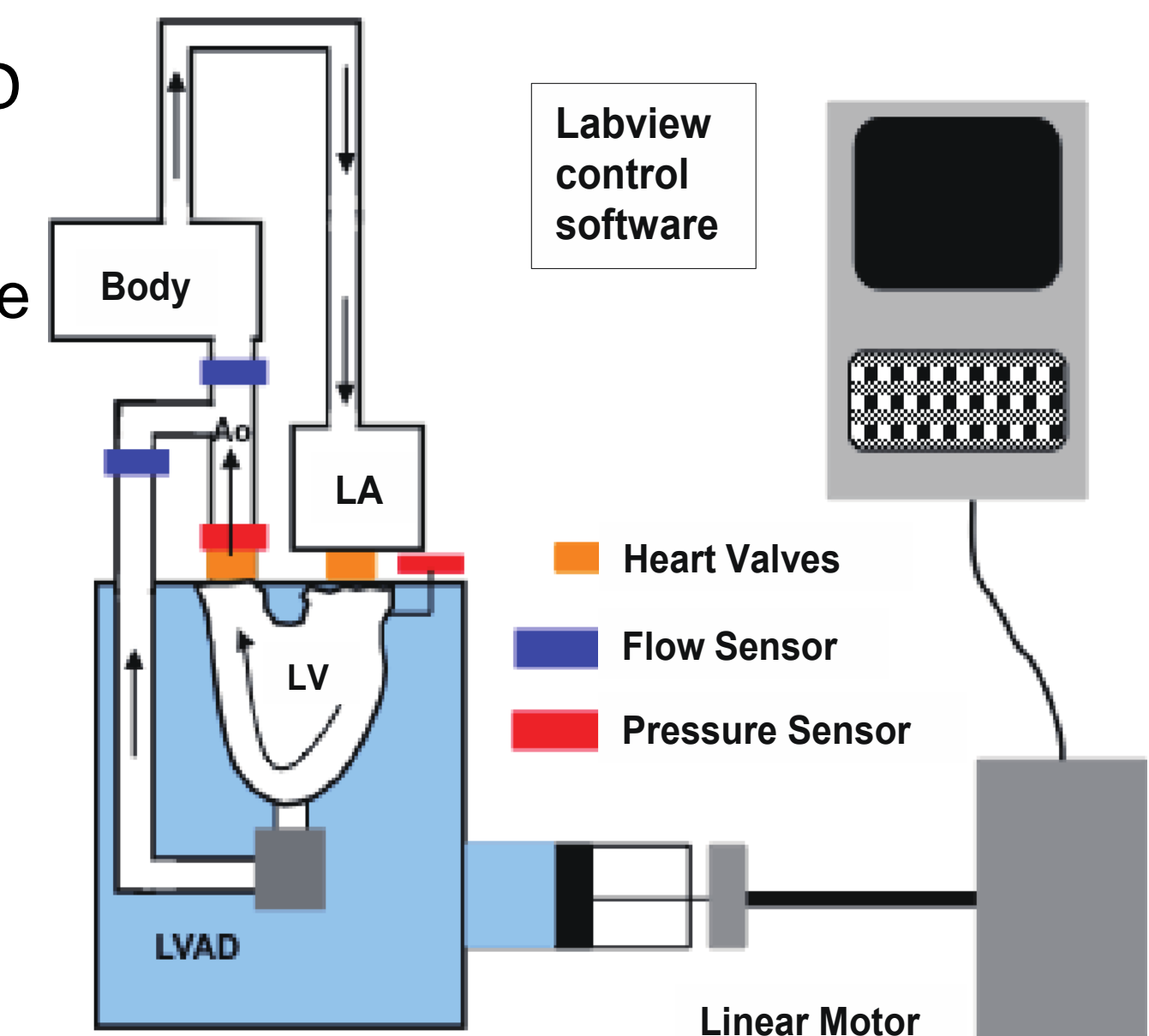


Figure 1. San Diego State University mock loop system.

- The circulating fluid was 40% glycerol, with the same density and viscosity as blood.
- AI duration was estimated from the recorded AV flow curve on a cardiac cycle, and regurgitant volume was determined from the estimated backward flow through the aortic valve based on velocity of aortic valve flow.
- AI durations and regurgitant volume were compared for each AI severity level between the Off LVAD and the On LVAD setting.

Results

Figure 1: Duration of AI for the Off LVAD vs. the On LVAD at 8,800 rpm for three AI severity level (mild, moderate and severe).

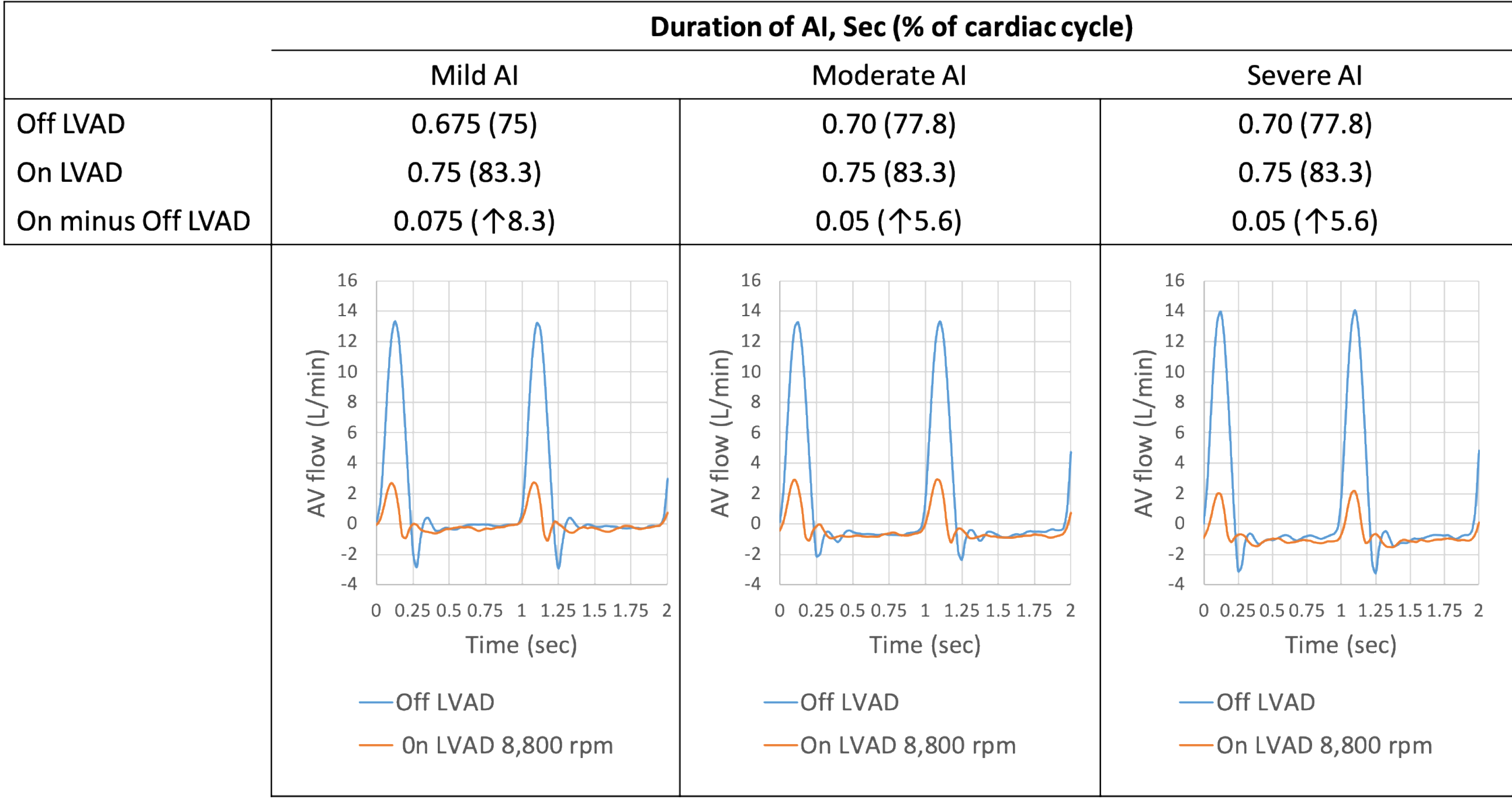
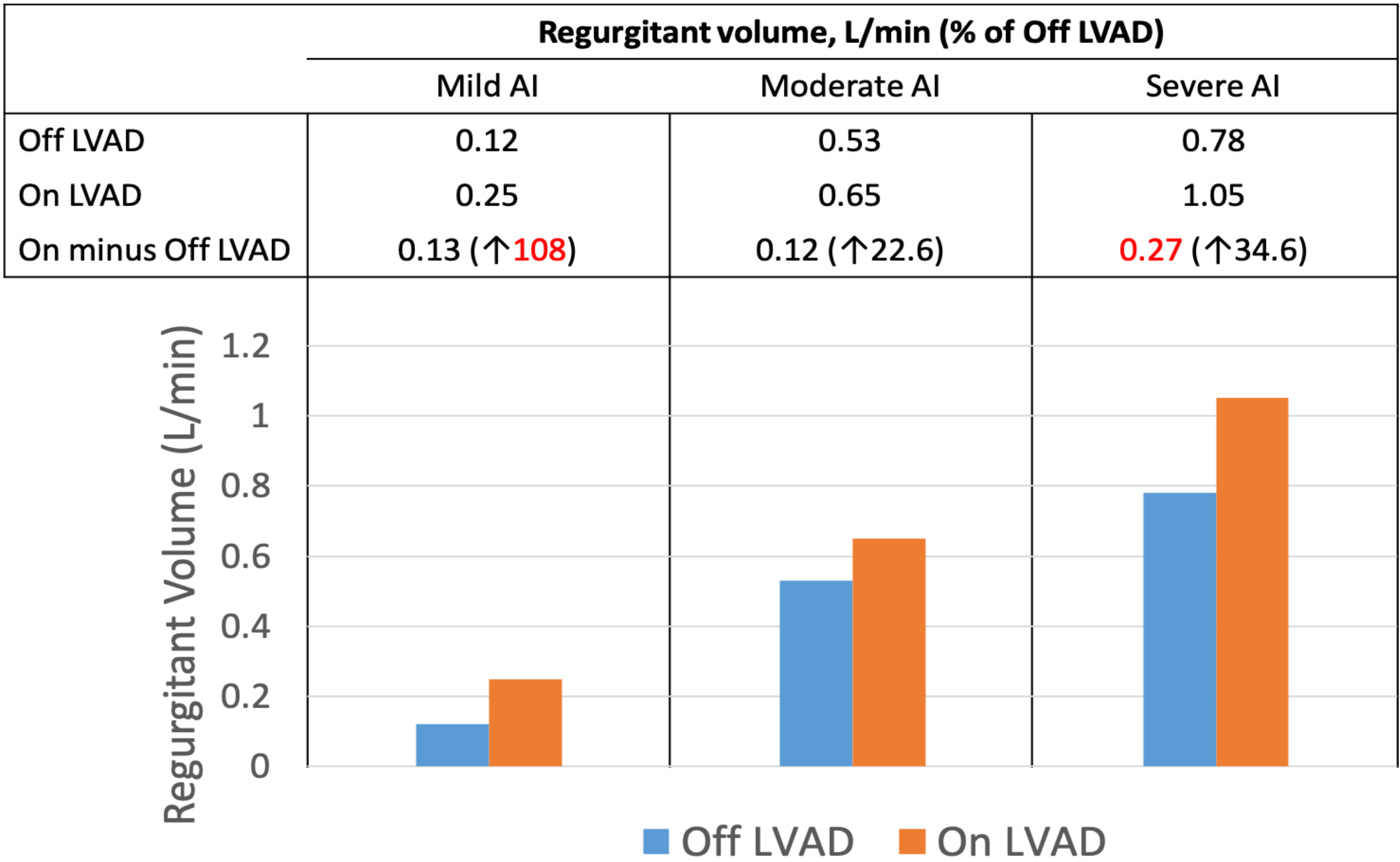


Figure 2. Regurgitant volume for the Off LVAD vs. the On LVAD for three AI severity level (mild, moderate and severe).



AI duration of a cardiac cycle (Figure 1)

- With the constant systemic resistance in the On LVAD setting at 8,800 rpm, duration of AI prolonged by 8.3% of a cardiac cycle (75 to 83.3%) with mild AI, 5.6% (77.8 to 83.3%) with moderate AI, and 5.6% (77.8 to 83.3%) with severe AI compared to the Off LVAD setting with the same severity of AI.

AI Regurgitant volume (Figure 2)

- In the On LVAD setting at 8,800 rpm, regurgitant volume of AI increased by 0.13 L/min (108.3%) in mild AI, 0.12 L/min (22.6%) in moderate AI and 0.27 L/min (34.6%) with severe AI compared to the Off LVAD setting with the same AI severity level.
- While the mild AI setting had the highest rate of regurgitant volume difference between the Off LVAD and the On LVAD setting for the three AI severity level (**108%**), the severe AI setting had the greatest increase in regurgitant volume (**0.27 L/min**).

Conclusions

In conclusion, this mock loop study demonstrated that AI duration was longer and regurgitant volume through the aortic valve was greater during LVAD support compared to the same AI severity level before LVAD. This suggests that the clinical burden of AI may be underestimated in patients with LVAD.

References

- Zoghbi WA, et al: Recommendations for evaluation of the severity of native valvular regurgitation with two-dimensional and doppler echocardiography. J Am Soc Echocardiogr 16:777-802, 2003.
- May-Newman K, et al: Biomechanics of the aortic valve in the continuous flow VAD-assisted heart. ASAIO J 56(4):301–308, 2010.
- Nishimura RA, et al: 2014 AHA/ACC guideline for the management of patients with valvular heart disease: executive summary: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines. J Am Coll Cardiol 63(22):2438-88, 2014.

Disclosure statement
Akinobu Itoh, Surgical advisory and speaker honorarium for Abbott, Medtronic and Abiomed.
All other authors have nothing to disclose with regard to commercial support.