

Background

Each year, approximately 280,000 patients worldwide undergo heart valve replacement surgery ⁽¹⁾. The far majority of these procedures involve mechanical or porcine/bovine fixed pericardium valve replacement, which have critical weaknesses regarding hemocompatibility, calcification or durability. Thus, there is no clear solution for pediatric and young-adult patients.

To tackle these problems, the Tranquillo Lab is developing a novel tissue-engineered heart valve (TEHV) that could recellularize, integrate itself into native tissue and consequently grow with the patient ⁽²⁾.



This development process calls for rigorous testing regime that can characterize heart valve parameters in real time in-vitro system. At the same time, it needs to remain flexible for the ever changing research purposes.

Project Goals

Aortic bioprosthesis valve requirements according to ISO 5840 standard ⁽³⁾:

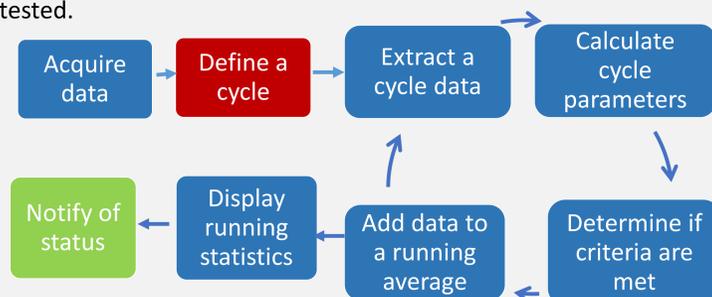
- Effective orifice area 1.2cm²:

$$A_{EO} = \frac{q_{vRMS}}{51.6 \times \sqrt{\frac{\Delta p}{\rho}}}$$

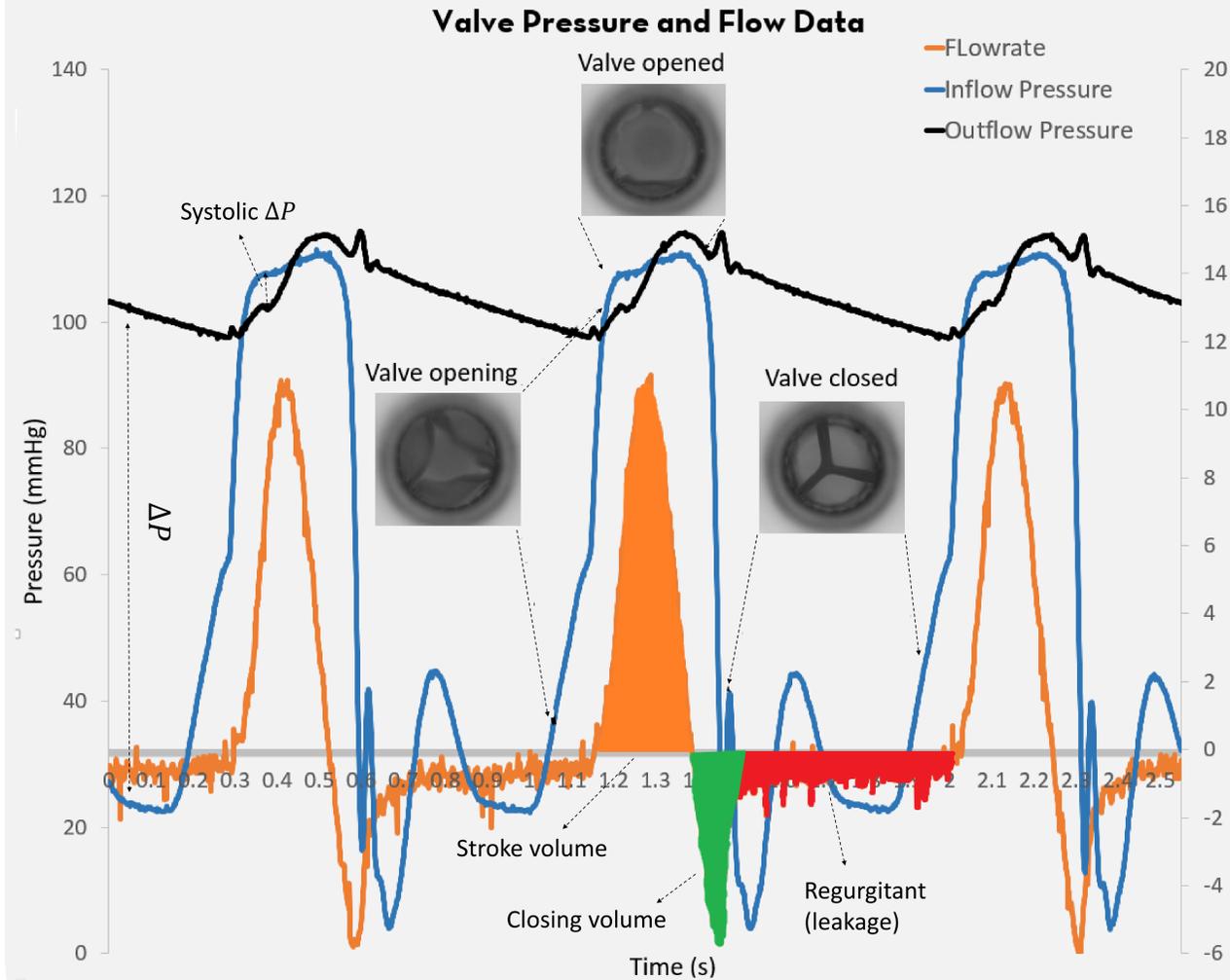
- Regurgitant fraction ≤ 10%.
- ≥ 95% of cycles reach the peak Δp of 100mmHg
- ≥ 5% duration of 100mmHg Δp in each cycle
- Custom parameters for researchers needs

Methods

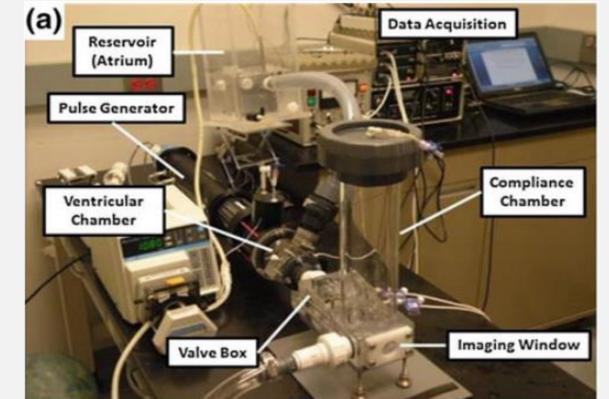
LabView platform will be utilized to program a code with the general strategy shown below. Cyclic flow condition is created by the Pulse Duplicator system. Different iterations of TEHV were tested.



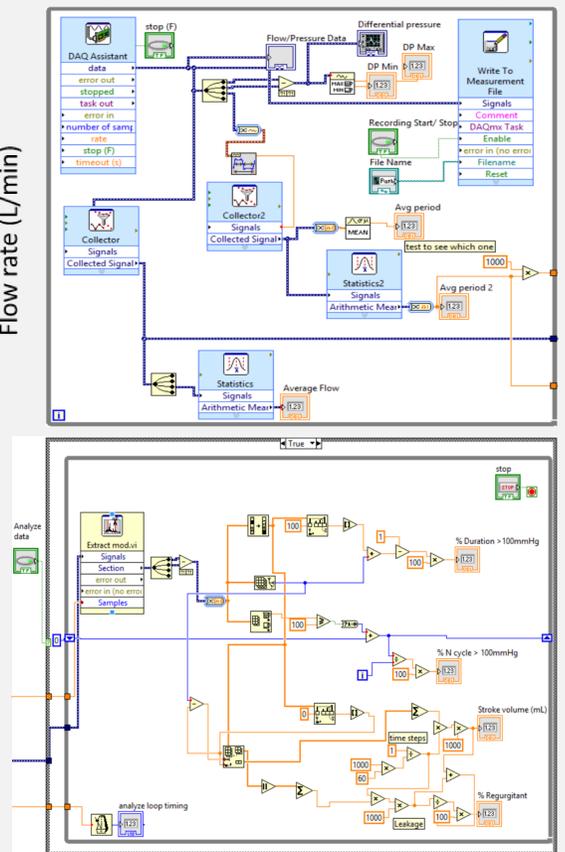
Results



Pulse Duplicator pressure and flow raw data (above) with important parameters and LabView block diagram setting (right) to process data in real time.



Tranquillo Lab's Vitro Pulse Duplicator system ⁽²⁾



Conclusions

- LabView code was implemented and displayed real-time valve parameters. Some functions are still left to be desired.
- Future work: More useful functions like failure notification, systolic pressure, orifice area, adaptation to venous valve, etc.

Reference

- 1, Pibarot, P., and J. G. Dumesnil. Prosthetic heart valves: selection of the optimal prosthesis and long-term management. *Circulation* 119:1034–1048, 2009.
- 2, Syedain Z, Meier L, Reimer J, Tranquillo R. Tubular Heart Valves from Decellularized Engineered Tissue. *Annals of Biomedical Engineering*. 2013; 41(12):2645-2654.
- 3, Cardiovascular implants — Cardiac valve prostheses. ANSI/AAMI/ISO 5840:2005, 13-14. Arlington, VA: Association for the Advancement of Medical Instrumentation, 2005.

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