CARDIOVASCULAR ENGINEERING RESEARCH:

DEVELOPMENT OF PROGRAMMABLE PULSATILE HEART PUMP

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ABSTRACT:
The use of ventricular simulation devices in cardiac research has been plagued with problems for years. Pumps are often only capable of sinusoidal wave patterns with little variance in overall shape. The cost of these pumps is also often prohibitive with basic pumps costing upwards of tens of thousands of dollars.

Developing a fully programmable and cost effective pulsatile pump is the ultimate goal of this project. The pump will greatly aid in the research conducted in the MDBL when used in conjunction with a mock flow loop. By using time variant flow control valves the pump will be able to adjust for every parameter needed in cardiac research. The pump will also integrate seamlessly into the mock flow loop system as it will be using the same software for control and data acquisition.

BACKGROUND

Various different companies have developed and produced ventricular simulation devices. The one used by the MDBL (multi disciplinary bioengineering lab) in Lb-161 is produced and sold by Harvard Apparatus. The device is a simple piston based pump with adjustable volume per stroke, rpm and ratio of systole to diastole flow.

This pump has been in use in the MDBL for approximately 1.5 years and has allowed for a significant amount of research to be conducted. However with the high cost of replacement parts and the lack of programmability, a new pump that better fits the needs of the lab at a lower overall cost is needed.

METHOD

In order to design the new pump a full set of design criteria was created.

1. The pump shall be fully programmable
2. The pump shall be able to function periods to time equal to 1+ hours.
3. The pump shall be able to be operated and programmed using LabVIEW
4. The pump shall be able to produce a flow pattern similar to that produced by a human heart.
5. The pump shall be capable of simulating abnormal human heart conditions.

Using these requirements an overall design was developed that would accomplish all required criteria.

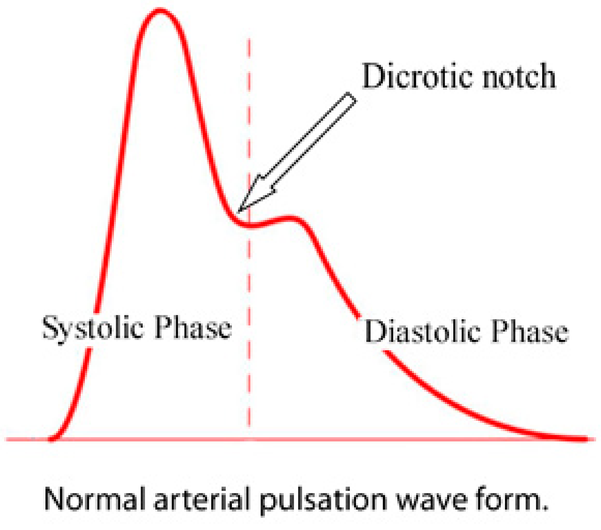
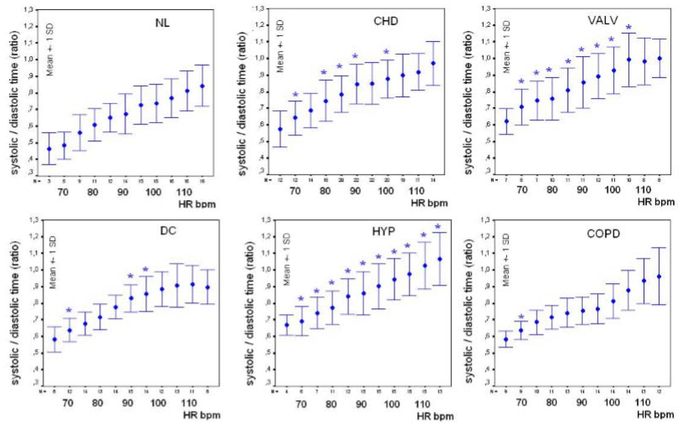


Figure 1: Standard waveform of the human heart

The pump will employ a two stage, 4 valve system. Stage one will be for control of the total flow rate to the loop. This stage will use two high torque proportional valves to adjust the percentage of flow going to the loop. Stage two will be the beats per minute and systolic/diastolic control stage also known as waveform control. This stage will also use a two valve system that will act in tandem to allow or divert flow from the loop as needed to create the appropriate waveform.

The control system will also be able to adjust for various heart conditions that associate themselves with variance in the systolic/diastolic ratio as heart rate changes



[valve pictures]

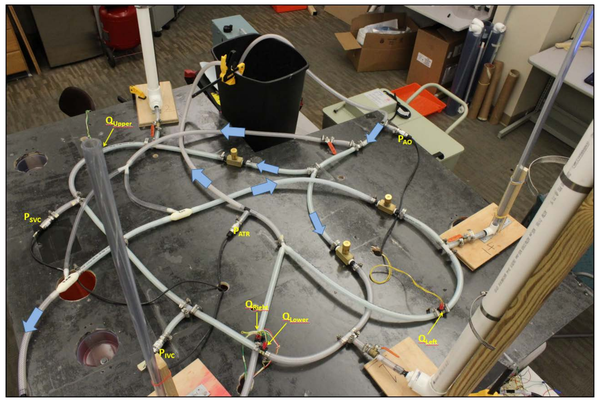
[simple diagram]

The pump will also incorporate a removable fluid tank to allow for various mediums to be used.

Since data acquisition is achieved through LabVIEW for the mock flow loop, the pump will also be programmed and operated in LabVIEW in order to make overall operation easier. This integration will also allow for the use of the already built in set of flow and pressure meters in order to verify that the pump is operating properly.

CONCLUSION

With the addition of a fully programmable pulsatile pump into the mock flow loop, the range and scale of cardiac research conducted in the MDBL will be greatly increased.



AKNOLEDGEMENTS
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