HydraPulse Massager 2.0

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Abstract

Surgeons performing surgery for extended periods of time will often experience muscle fatigue. This fatigue is primarily the result of the venous circulatory system having to work against gravity to effectively pump blood from the legs. [1] The device is being developed with the objective of providing a massage to specific points on the calf. The devices uses a fluid mechanism to provide point pressure--replicating the sensation of the finger pressing massage technique associated with the Shiatsu massage. The original device, the HydraPulse Massager 1.0, established the feasibility of the fluid mechanism to provide point pressure. The drawback of whole predicate system, however, was the necessity to store its components in a large backpack. [2] The backpack element of the design was its downfall as it became incompatible for the operating room. The HydraPulse Massager 2.0 device aims to eliminate the drawbacks of the previous design (Hydrapulse Massager 1.0) while providing additional benefits and accentuating its existing functionality.

Solution: To address this issue, the team has taken the well-defined user needs stated above as well as the functional strengths of the previous design and translated them into design inputs. These inputs ultimately resulted in various design outputs, the feasibility of which were tested to obtain an optimal combination of the prospective outputs. Ultimately, a device was created with the capability of addressing the issue of diminished venous return from the calf. This device consists of various subsystems including electrical, hydraulic, mechanical, software and the user interface. The Hydrapulse Massager 2.0 uses an Arduino-controlled electromechanical actuator. The actuator is attached to a syringe plunger which is connected to the syringe system to force fluid flow through the tubing architecture. The tubing then branches out in order to connect to the eight balloons housed in the balloon encasement tablet. Inflation of the balloons is modulated by solenoid pinch valves which are also controlled through the circuitry and Arduino microcontroller.

Customer Needs

- Fit underneath surgical garments and below the thigh.
- Should mimic deep tissue calf massage technique.
- Should be tolerable during operative procedure.
- Maintain position on leg during operative procedure.
- Minimize any unanticipated adverse reactions.
- Allow the user to walk from dressing room to operating room.
- Should provide instructions for use and maintenance.
- Hands-free operation.

Design Concept

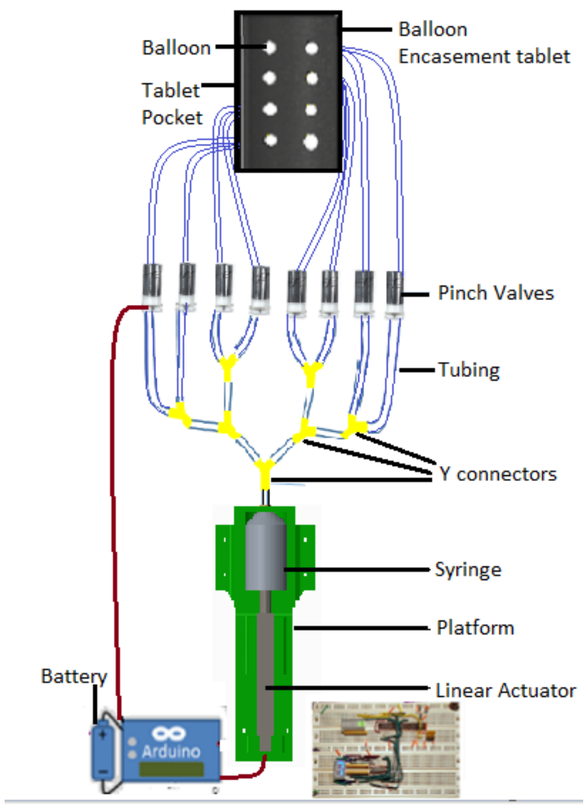


Figure 1: Overview of system design

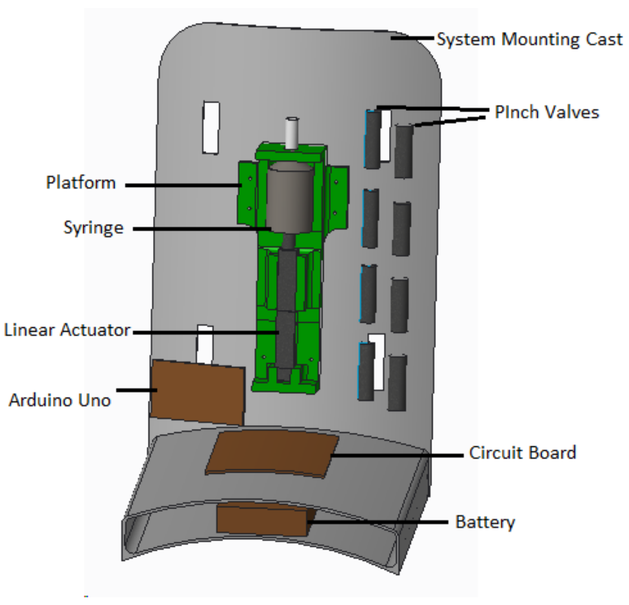


Figure 2: Overview of system mockup design

- Fluid mechanism to provide pressure during massage
- Polyisoprene balloons to mimic finger pressing
- Flexible balloon encasement tablet to hold balloons and tubing
- Solenoid pinch valves to modulate fluid distribution in balloons via tubing
- Linear actuator utilized with a compact, low-profile syringe to push fluid
- Arduino-governed circuit and system to operate the device

Future Plans

- Invention Disclosure completed 1Q17
- Patent application filing 2Q17
- Design finalized 3Q17
- Commercialization planned 1Q18

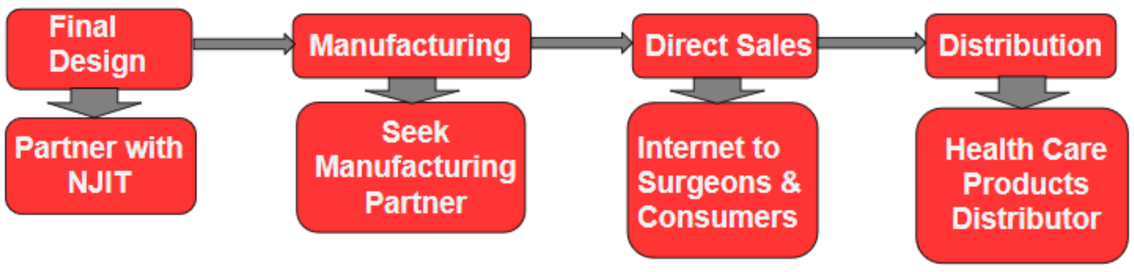


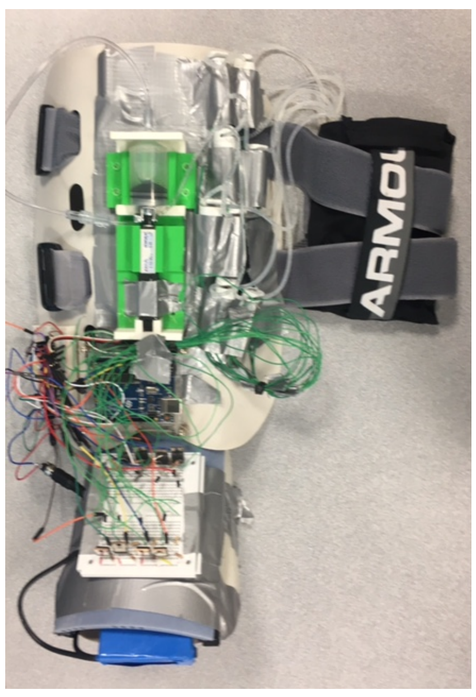
Figure 3: Detailed flow chart depicting future plans

Test Plan

Test	Requirements	Pass/Fail
Physical Design Size Measurement to fit under surgical garment	Balloon Encasement Tablet, Balloons, Platform, System Mounting Cast	Pass
Battery Compatibility	22 V	Pass
Linear Actuator Output	80 N	Pass
Linear Actuator Frequency	0.1 Hz	Pass
Minimum Pressure Output	5 Psi	Pass
Pinch Valves Frequency	0.1 Hz	Pass
Massage Modes	Sequential Massage Mode Alternating Massage Mode Speed Control Mode	Pass

Figure 4: Test Plan Chart

Innovation



- Electrical components housed on the top surface of the frame
- Syringe-actuator support
- Eight pinch valves along the lateral side of the frame
- Balloon encasement tablet held by adjustable straps
- Arduino-controlled fluid & mechanical mechanisms

Figure 5: HydraPulse Massager 2.0

Acknowledgement

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References

[1] Occupational Employment and Wages, 29-1067 Surgeons. (2015, May).
[2]"A Shortage of General Surgeons: Coming Soon?" Physicians Weekly. N.p., n.d. Retrieved October 13, 2016.