Team #20

Creighton UNIVERSITY School of Medicine

Smart Tourniquet for Acute Trauma (STAT)

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Background & Mission Statement

- Tourniquets are utilized in 90% of traumatic lower extremity injury cases.
- Field tourniquet application can result in permanent tissue and nerve damage in 23% of patients which is associated with overtightening and improper application [1].
- Our device aims to prevent overtightening by continuously monitoring the presence of blood flow with a pressure sensor and adjusting the applied pressure through our torque motor.

At STAT Innovations, we seek to create automated medical device systems that ensure better patient outcome through ease of use and active sensing systems.

Final Product Specifications

Parameter	Target Values	Acceptable Ranges
Maximum Pressure	300 mmHg	250 - 400 mmHg
Tightening Time	< 30 seconds	< 45 seconds
Release Time	< 1 second	< 3 seconds
Pressure Retention	< 3% drop/hour	< 5 % drop/hour
Operational Temperatures	(-17) - 50 °C	0 - 45 °C
Storage Temperature	(-20) - 60 °C	0 - 45 °C
Battery Life	> 10 hours	> 6 hours
Device Weight	< 2 kg	< 4 kg
Sensing Accuracy	< 3 % error	< 5c% error

Table 1 | This table summarizes our final product specifications for the SMART Tourniquet. These values are determined based on benchmark testing.

Final Technical Model

The tightening system coordinates with the feedback loop to reduce tissue and nerve damage for the safest tourniquet application.

$$\textit{Final Tightening Integral} = \int_0^{2\pi N} \sqrt{\left(R_0 + \frac{d}{\pi}\theta\right)^2 + \left(\frac{d}{\pi}\right)^2}\theta \, d\theta = M$$

Equation 1: Tightening Integral

A piezoresistive micro pressure sensor will be utilized for signal acquisition of the oscillatory waveform produced by blood flow in the femoral artery.

$$V_{out} = P\frac{L^2}{t^2}(1 - v)\pi_{44}V_{in}\ (V)$$

Equation 2: Voltage Output of Wheatstone Bridge

$$\frac{\Delta R}{R} = \pi_L\sigma_L + \pi_T\sigma_T$$

Equation 3: Fractional Change in Resistance

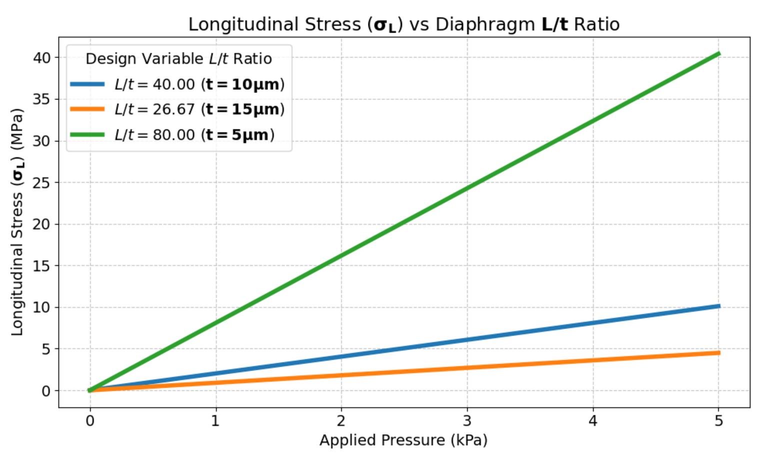

Figure 1 | Relationship of sensor diaphragm dimensions effect on longitudinal stress

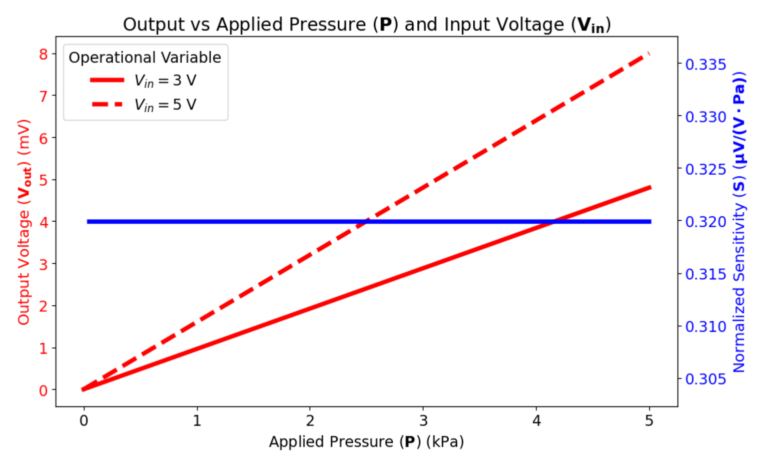

Figure 2 | Describes the effect of excitation input voltage and pressure to electrical signal output

Prototype

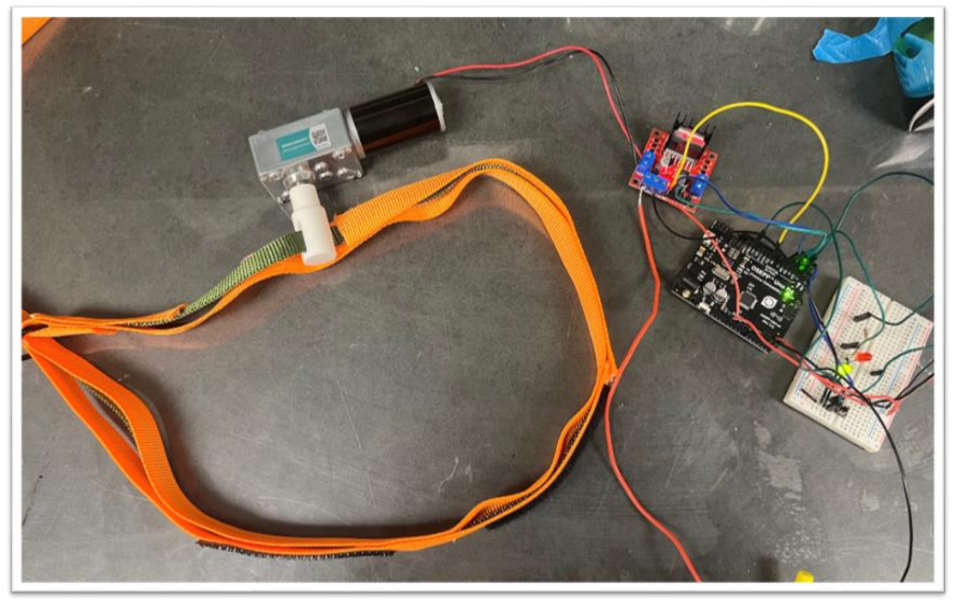

Figure 3 | The tourniquet band → motor → Arduino interface

Tightening Band:

Demonstrated controlled and repeatable tightening of the tourniquet band through integration of a torque-driven motor system. This design allows for fine-tuned adjustment of pressure, reducing user variability and improving reliability in achieving effective arterial occlusion while minimizing the risk of over-tightening.

Figure 4 | Bench used for alpha prototype testing with all electrical and mechanical components

Sensing System & Tightening Band:

Demonstrated integrated real-time signal acquisition and processing, enabling continuous monitoring of physiological data to assess arterial occlusion. The sensing system communicates feedback directly to the motor-controlled tightening band, allowing dynamic adjustment of applied pressure.

Verification Results

Test Bench Specifications

- Blood pressure 130/70 mmHg
- Silicon tubing 6.36 mm ID
- Estimated 90 bpm
- Trials in 15 s intervals
- Bladder 3.9" x 5.9"
- Nine successive pressures tested

Sensor Verification Testing

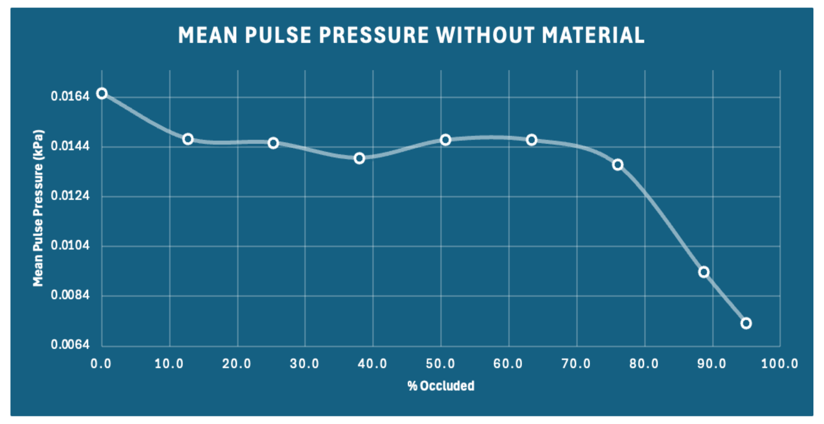

Figure 5a. Shows pulse pressure without material layer as occlusion approaches.

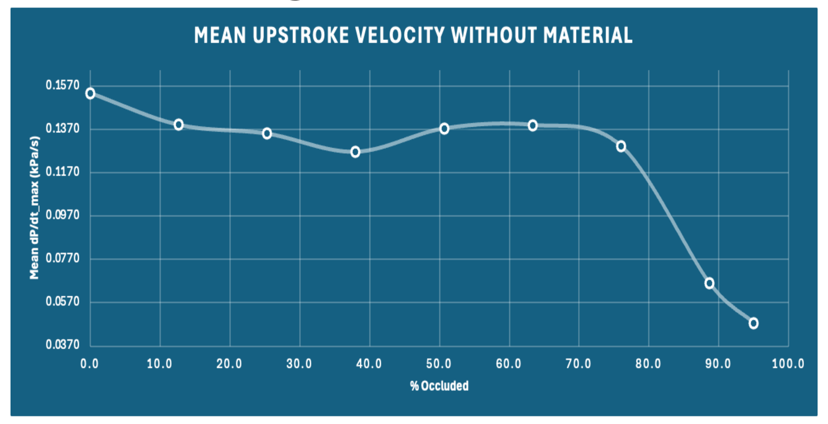

Figure 6a. Shows upstroke velocity without material layer as occlusion approaches.

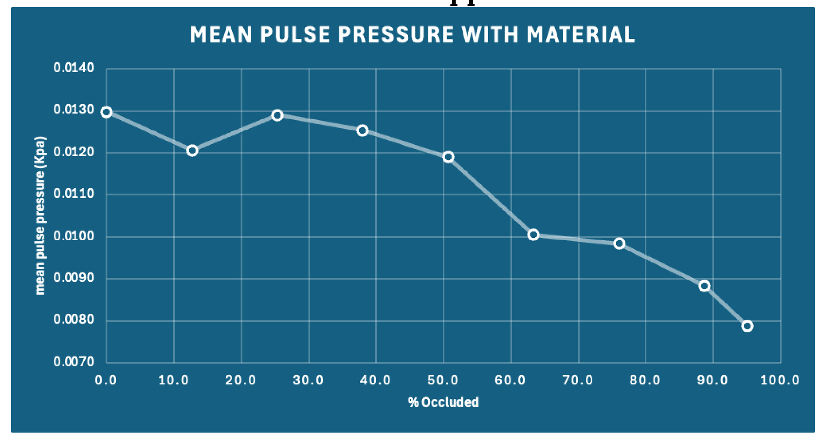

Figure 5b. Demonstrates pulse pressures with skin and tissue material.

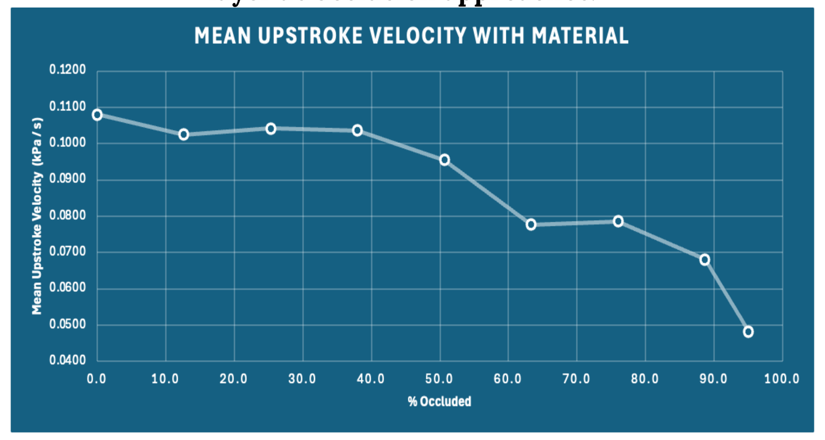

Figure 6b. Demonstrates upstroke velocity with skin and tissue material.

Results indicate the micro pressure sensor can effectively guide the tightening system using thresholds at an estimated 90% occlusion. Both metrics above show trends consistent enough to use as a double indicator, meaning safer and more consistent occlusion validation.

Dominant Concept

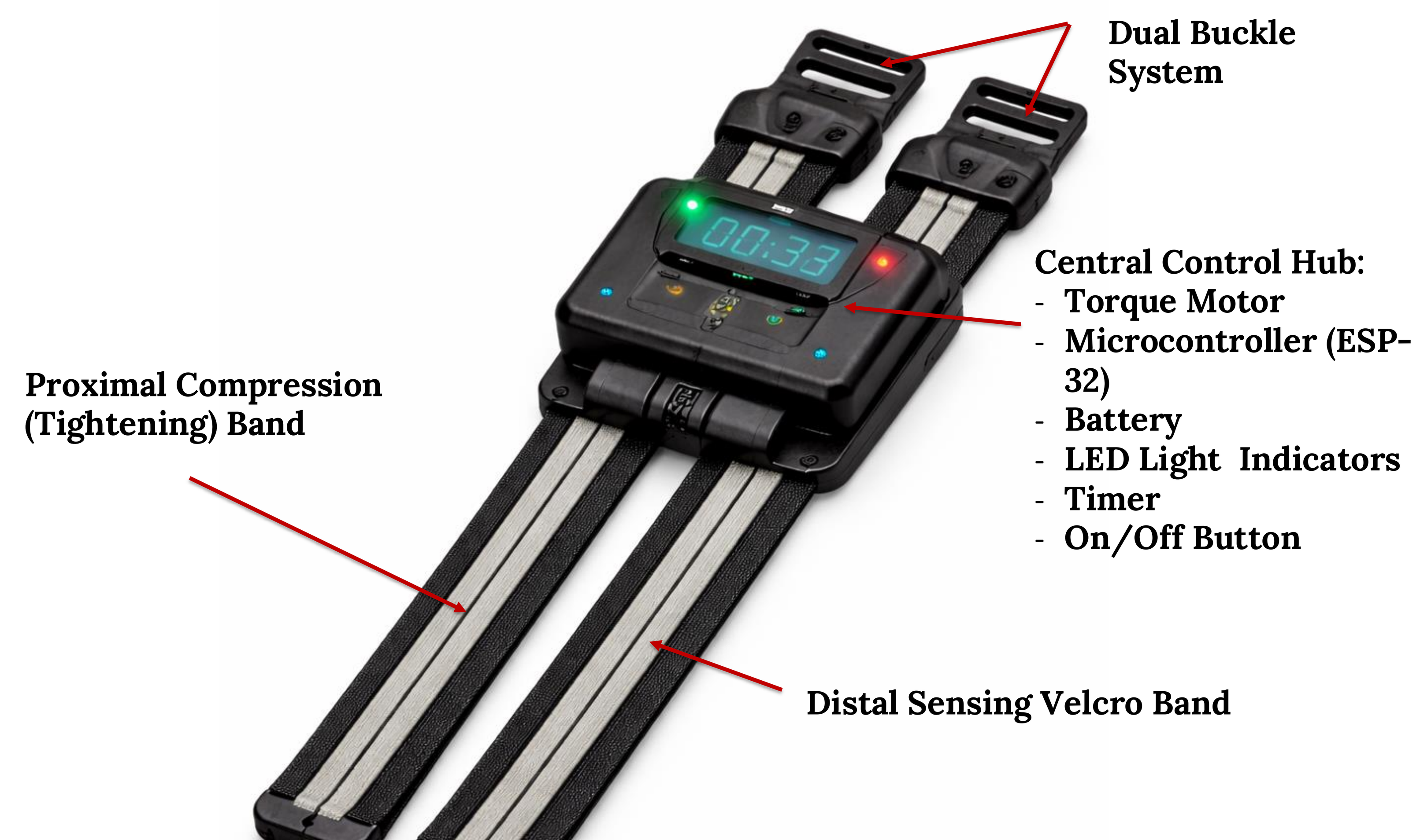

Figure #7: STAT Tourniquet Model Rendering

This device model features a dual-band cuff system, including an inner compression band and an outer Velcro cuff for secure placement. A built-in torque motor tightens the inner band to gradually reduce blood flow, while an integrated MEMS sensor, strategically positioned on the distal band, continuously monitors for pulsatile signals downstream of the compression site. This device also incorporates a timer and a light to indicate that occlusion has been reached for live feedback. The system then continues to monitor for any return of blood flow, allowing for responsive adjustments if needed. Powered by an onboard battery and controlled by a microcontroller, this smart tourniquet offers a more controlled, efficient, and dependable solution compared to traditional manual devices.

Future Steps

"STAT envisions a tourniquet that delivers faster, reliable hemorrhage control anywhere- ready to save lives when every second matters"

Validate consistent isolation of femoral artery pulses on live patients in a clinical setting. → Improve the design to be as small, lightweight, and affordable as possible → Expand the application to upper limb extremities

Complete Project Timeline

GANTT Chart

The project timeline and major milestones are highlighted in the team's GANTT Chart. This GANTT Chart demonstrates our team's approach to the success of our team's timeline. This timeline begins at the start of BME 490 in January of 2026.

Acknowledgment and References

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[1] M. Rittblat, S. Gendler, N. Tsur, I. Radomislensky, A. Ziv, and M. Bodas, "The cost of saving lives: Complications arising from prehospital tourniquet application," *Academic Emergency Medicine*, vol. 32, no. 5, pp. 532–541, 2025, doi: 10.1111/acem.15070. [2] T. Hersh, B. Friedman, W. Luczyk, and J. Sesing, "Evaluation of filtering methods for acquiring radial intra-artery blood pressure waveforms," *J. Clin. Monit. Comput.*, vol. 29, pp. 659–669, Oct. 2015, doi: 10.1007/s10877-014-9649-4.