Smart Tourniquet for Acute Trauma

Nathan Amyot[1*], Colton Davis[1], Cohen Jeffries[1], Joseph Rodriguez[1], Colin Stafford[1]
Dr. Gaby Iskander[2], Nidhi Ramesh[2], Dr. Sarah Stabenfeldt[1]
[1]Ira A. Fulton Schools of Engineering, Arizona State University, [2]Creighton University School of Medicine

Team #20 STAT

Creighton UNIVERSITY School of Medicine

Ira A. Fulton Schools of Engineering
Arizona State University
School of Biological and Health Systems Engineering

Clinical Problem

- 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 whish is associated with overtightening and improper application.
- 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.

Market Segment & Customer Needs

The global tourniquet market was evaluated at USD 502.0 million in 2024, estimated to reach 794.7 million by 2030, with a CAGR of 8.0%. The North America market revenue was 45.5% of the global market in 2024 [1].

Of the sixteen customer needs, the most important were defined as reaching femoral occlusion consistently, maintaining occlusion without pressure drift, no mitigation of the device, universal application across thigh sizes, automatic pressure control, and automated application. See HOQ for full list of customer needs.

Engineering Specifications

Parameter	Target Values	Acceptable Ranges
Maximum Pressure	260 mmHg	250-350 mmHg
Tightening Time	≤20 seconds	≤45 seconds
Release Time	≤1s	≤2s
Pressure Retention	≤3% drop/ hour	≤5% drop/hour
Tensile Band Strength	≥ 15,300 N	≥ 11,000 N
Usable Temperature	+20°C	+30°C
Operation Temperatures	-17 -50°C	0-45°C

Table 1: This is the table of our target Engineer Specifications for the STAT Tourniquet. These values are determined based on meeting and surpassing the current competitor values.

Manufacturing Cost

Description	Price
DC High Torque Motor	$21.50
Adafruit Driver Board	$7.50
ESP 32	$8.99
Buck Converter (x2)	$2.48 x 2 = $4.96
Battery	$18.99
Nylon Webbing	$14.99
MEMS Sensor	$15.00

Estimated Cost Per Unit	$92.00

Table 2: These are plausible manufacturing costs based on retail prices. This cost discounts the labor of assembling the tourniquets

MEMS Pressure Sensor

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

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

Equation 1: Voltage Output of Wheatstone Bridge

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

Equation 2: Fractional Change in Resistance

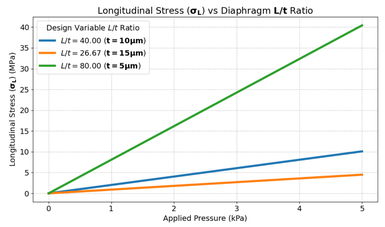


Figure 1 | Relationship of sensor diaphragm dimensions effect on longitudinal stress

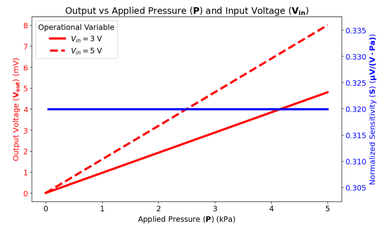


Figure 2 | Describes the effect of excitation input voltage and pressure to electrical signal output

Tightening System

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

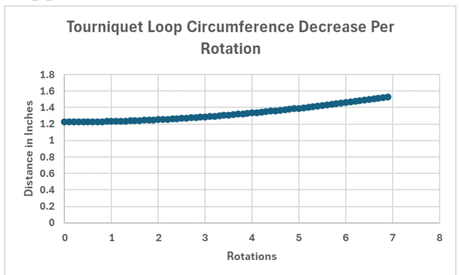


Figure 3 | Decrease of the tourniquet loop circumference per rotation of the tightening system

- Our model translates the motors torque to a decrease in tourniquet loop length to apply force for limb occlusion
- Simulated outputs will be compared to literature providing 190-230 mmHg of force

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

Equation 3: Tightening Integral

Feedback Loop & Compensation Filter

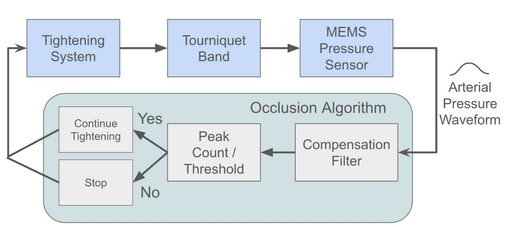


Figure 4 | Block diagram of the feedback loop system that illustrates how the occlusion algorithm uses the input signal to reach occlusion in the femoral artery [2].

$$C(s) = \frac{s^2 + 2\zeta_m\omega_m s + \omega_m^2}{s^2 + 2\zeta_0\omega_m s + \omega_m^2}$$

Equation 4: Transfer Function of the Compensation Filter

Dominant Concept

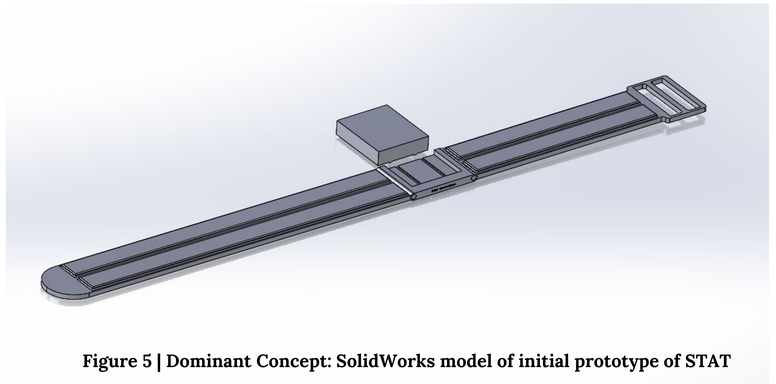


Figure 5 | Dominant Concept: SolidWorks model of initial prototype of STAT

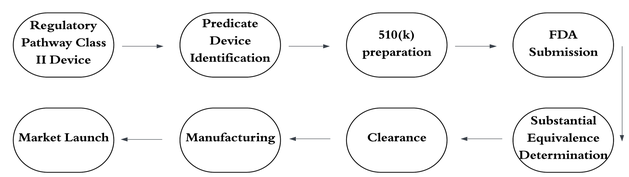
This model utilizes a dual-band system consisting of an outer velcro cuff and an inner motor-driven compression band. The MEMS sensor is set within an airbladder which is placed in the distal band so it can detect pulsatile blood flow to determine when arterial occlusion is properly reached. This design incorporates a removable battery and a cuff constructed from simple stitched textiles, keeping the system lightweight, portable, and low-cost.

GANTT Chart – House of Qualities (HOQ)

GANTT Chart HOQ

The project timeline and major milestones are highlighted in the team's GANTT Chart. The HOQ highlights our Critical to Quality (CTQ) customer and technical requirements and shows how our current design iteration compares to competitors on the market.

Regulatory Pathway



Future Work

Virtual and Physical prototyping → Standardized testing to assess feasibility → Adjustments / improvements to design → Expand the scope to upper limb extremities

Acknowledgment and References

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[1] Grand View Research, "Tourniquet Systems Market Size, Share & Trends Analysis Report, 2024–2030," Grand View Research. Accessed: Nov. 16, 2025. [Online]. Available: https://www.grandviewresearch.com/industry-analysis/tourniquet-systems-market [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.