The Thrombectomers: Update 5

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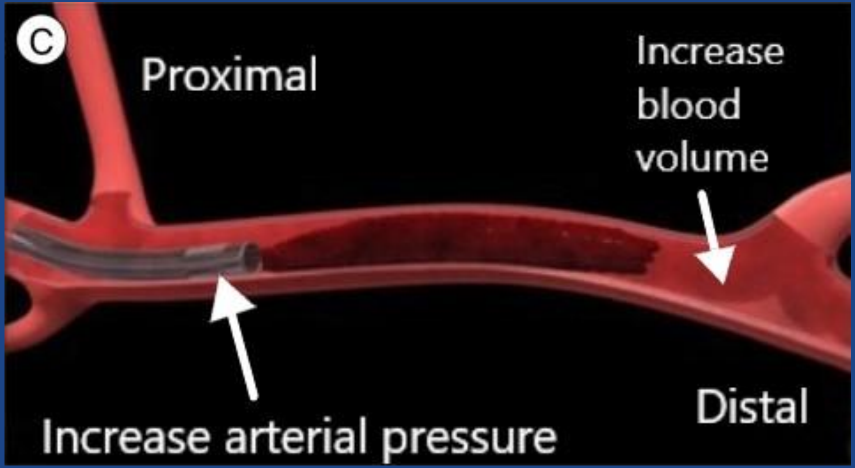
Problem Statement

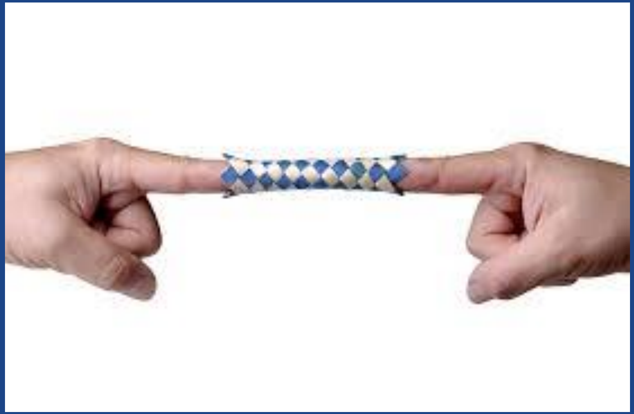
- Vacuum Thrombectomy: Procedure to remove cerebral thrombi using vacuum pressure
  - 23 minutes faster than stent retriever thrombectomy
- There remains room for the procedure to be optimized.
  - Current success rate: 78%
- Need a physical model of the cranial cavity that accurately represents ICP, and allows for alteration of pressure to determine the suction force at the tip of the catheter.

Movie

Our Theory

- Increase ICP by blocking jugular flow
  - Monro-Kellie doctrine: the cranial compartment is incompressible and the volume inside the cranium is fixed
- 2 mechanisms:
  1. Increase arterial pressure proximal to the clot
     a. Allows the surgeon to pull more vacuum pressure => more suction force
  2. Increase blood volume distal to the clot/reduce pressure gradient across the clot
     a. Similar to Chinese finger trap





Needs Assessment

- Model Efficacy
  - Must accurately model and measure intracranial pressure (ICP)
  - Must accurately model blood vessel shape and size in which the vacuum catheter will be inserted
  - Must respond to an increase in ICP in a manner that accurately replicates physiology and anatomy
  - Must accurately model blood flow through vessels in the brain during normal conditions as well as during elevated ICP conditions.

- Cost Efficacy
  - Model should be reusable and affordable

- Medical Provider Compatibility
  - Ability for physicians and students to practice thrombectomy on the model

Gantt Chart

Task	Start Date	End Date	Timeline	Hours
Overall time period	9/26	4/23		
Time Period of work for this presentation	2/22	3/13		
Meet with Dr. Froehler weekly	9/26	4/23		160
Brainstorm ideas for initial prototypes	9/26	11/30		60
Settle on initial model design	10/18	11/8		30
Order Parts	11/1	4/1		60
Build first prototype	11/14	12/8		32
Evaluate efficacy of first model	12/8	1/10		20
Improve upon first model	12/19	1/17		20
Create second prototype and iteratively improve	1/10	3/5		120
Collect and analyze data	2/7	4/7		40
Run experiments with direct aspiration catheter	2/19	3/31		30
Create System for evaluation of suction force tests	2/19	3/1		12
Finalize model	3/5	3/22		10
Put together poster for Design Day	4/1	4/23		40
If applicable begin marketing and trials	4/7	4/22		40
Present at Design Day	4/22	4/23		15

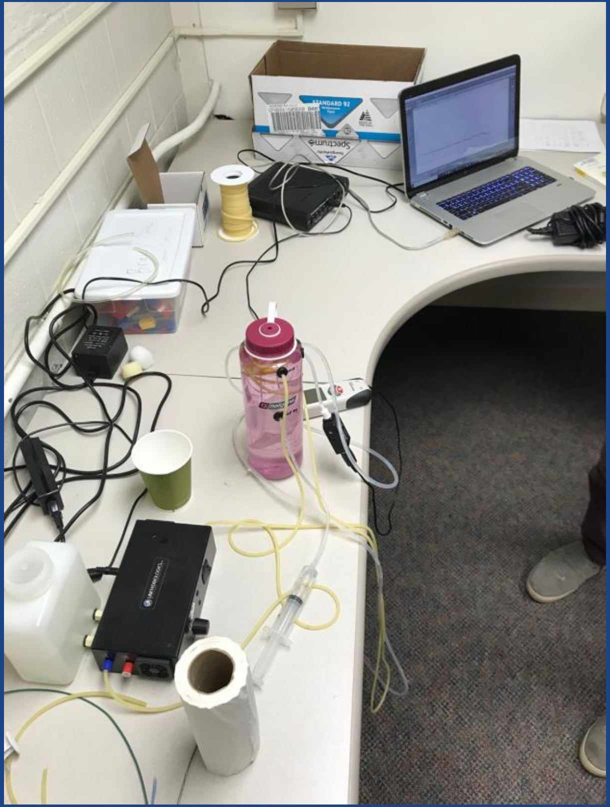
Review of Previous Accomplishments

- Creation of 2 distinct prototypes
  - Iteration 5 of current prototype
- Data measurements with continuous flow
  - No significant relationships between ICP under 25 mm Hg and either gauge or differential pressures.
- Performed atmospheric suction force tests
  - Now that latex tubing has come in, these can be compared with higher than atmospheric pressure suction tests.

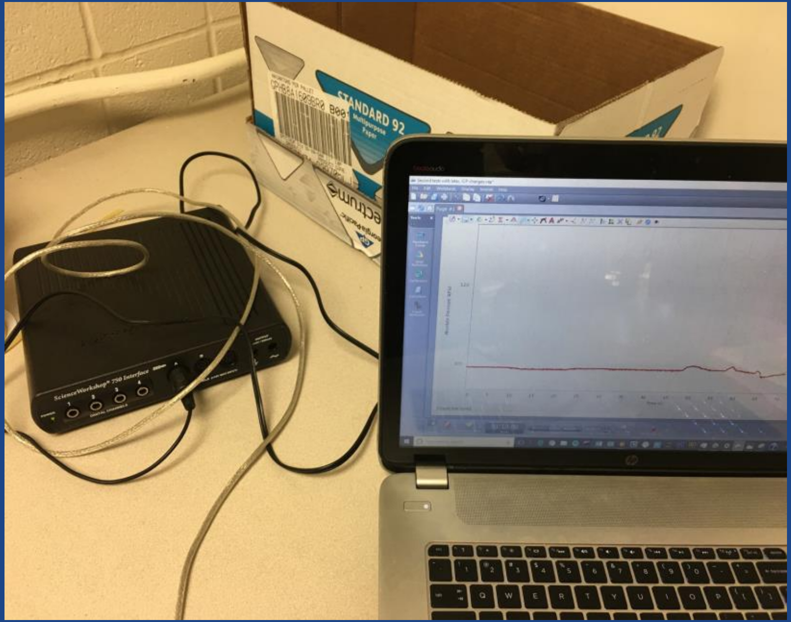
Model improvements since last presentation

+ Addition of new latex tubing
  - ⅛” (3.175 mm) ID, 1/32” (0.79mm) wall thickness
  - “Feels like an artery”   -Michael Froehler, M.D., Ph.D.
  - Experiments reveal changes in luminal pressure with a change in ICP
+ Implementation of digital absolute pressure gauge
  - Borrowed from Dr. Charnock in the physics lab
  - 20 Hz sampling rate over a greater pressure range which directly outputs to an industry standard software application

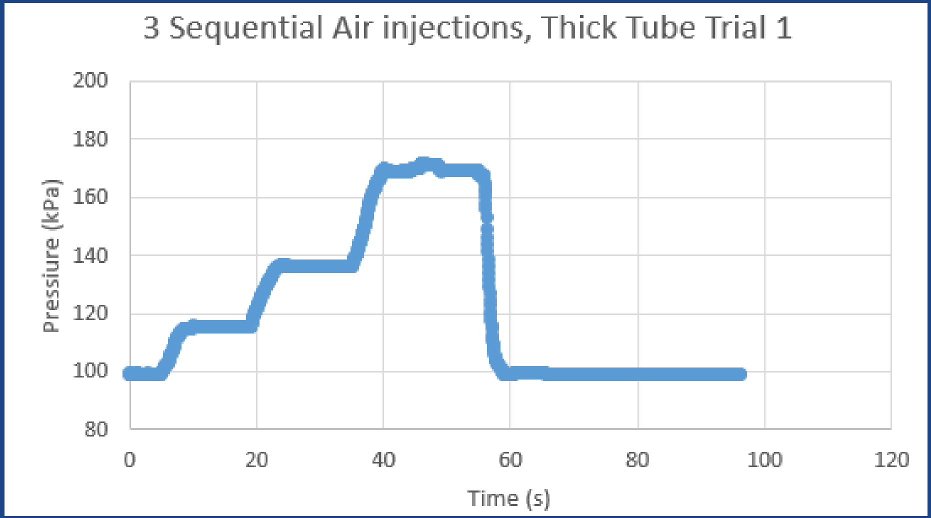
– Decrease in model efficacy: loss of our pulsatile pump.
  - We were able to obtain several gigabytes of raw data before returning the pump that can be analyzed in the time in between obtaining a new pump

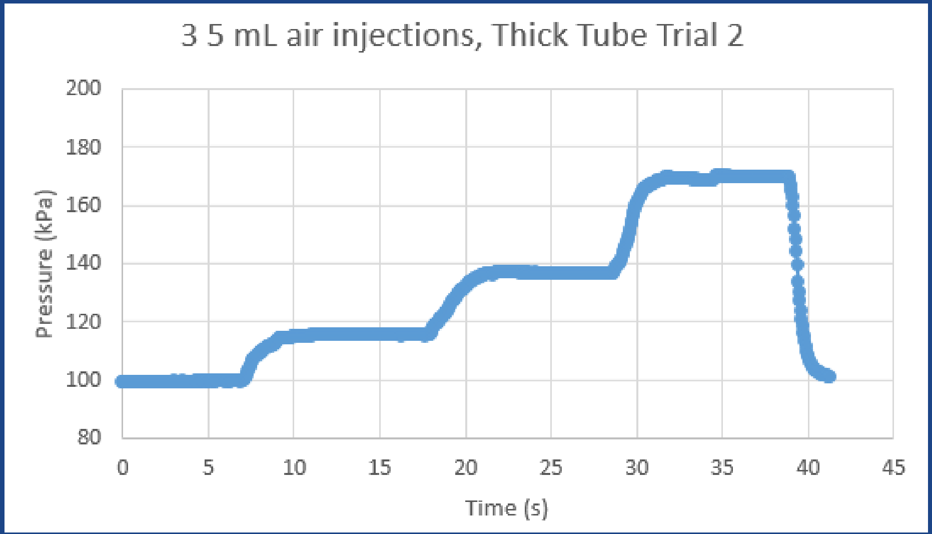


Initial Tests with Continuous Pressure Gauge

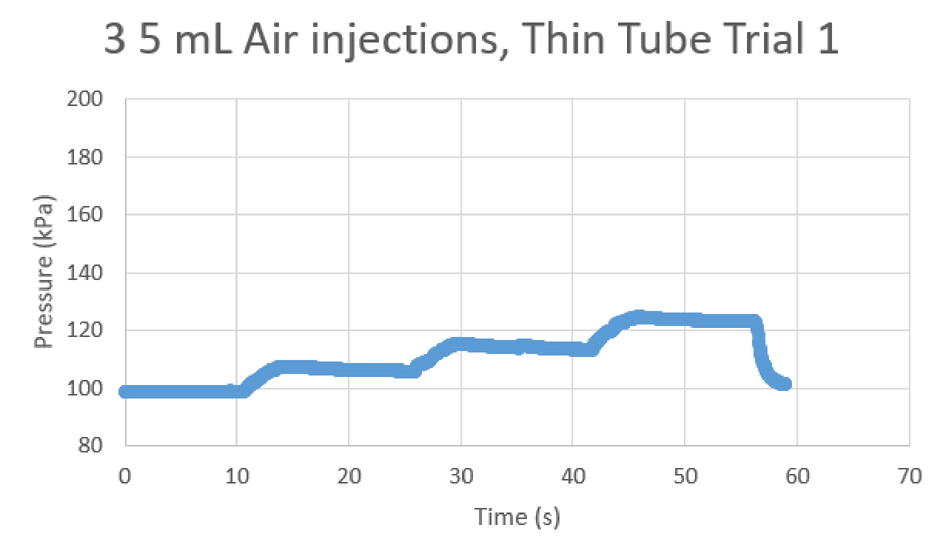


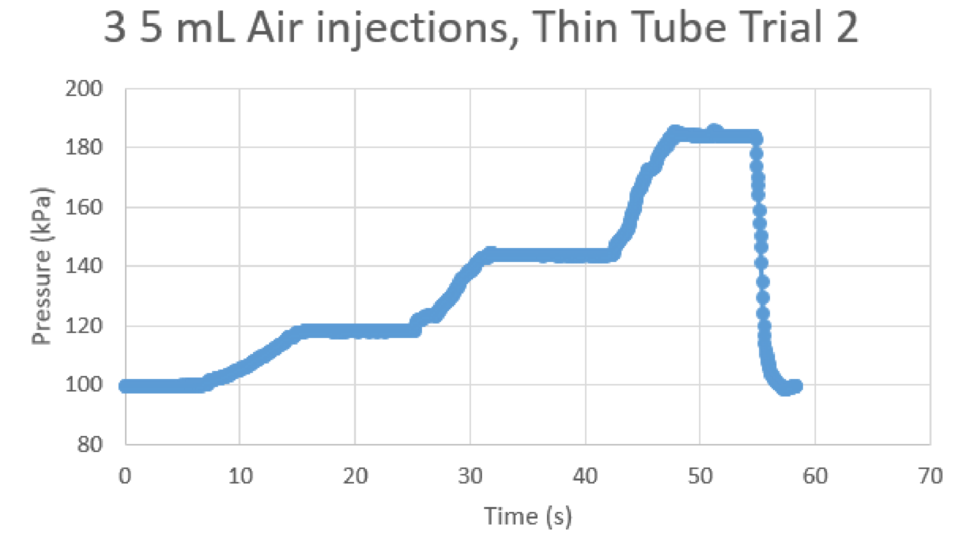
Thick Tube Trials show constant pressure readings following air injections with repeatability





Thin Tube Trials show constant pressure readings following air injections except with less consistency

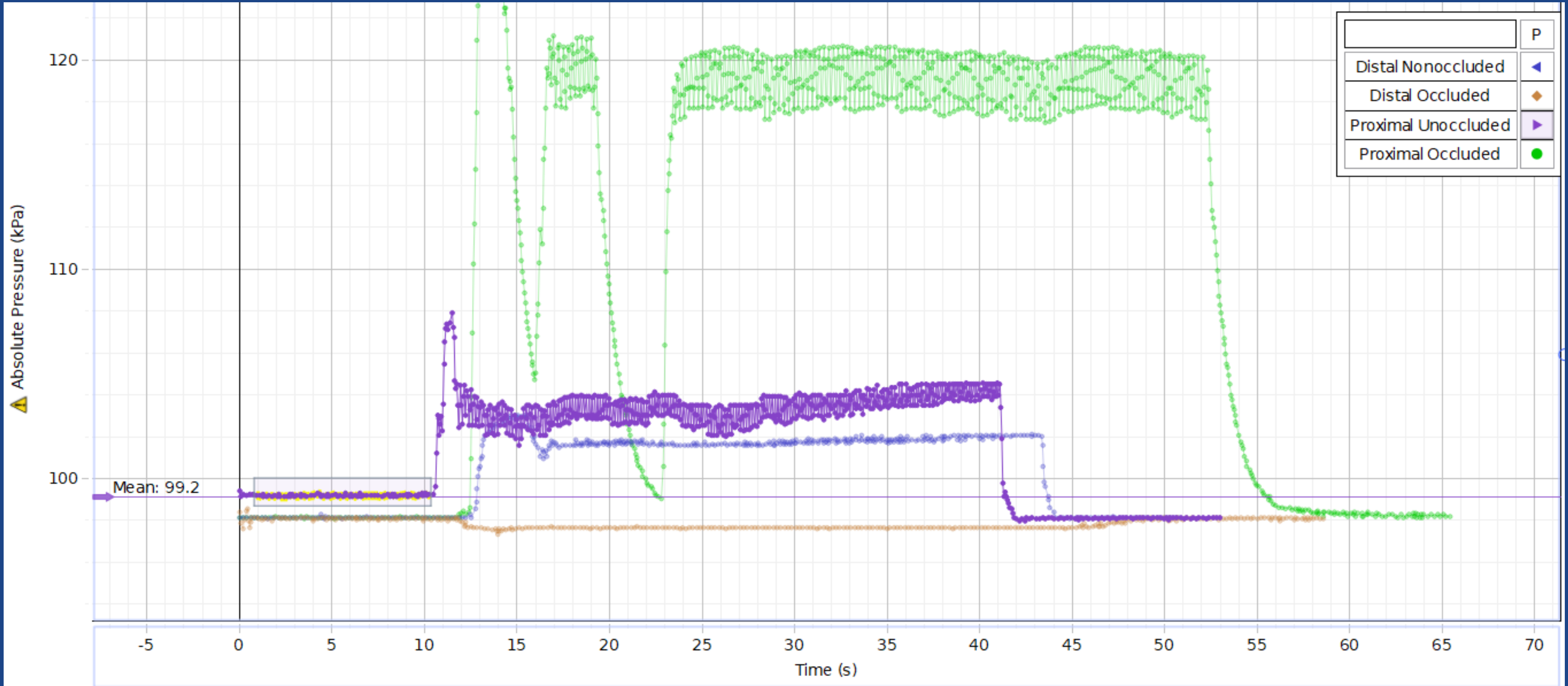




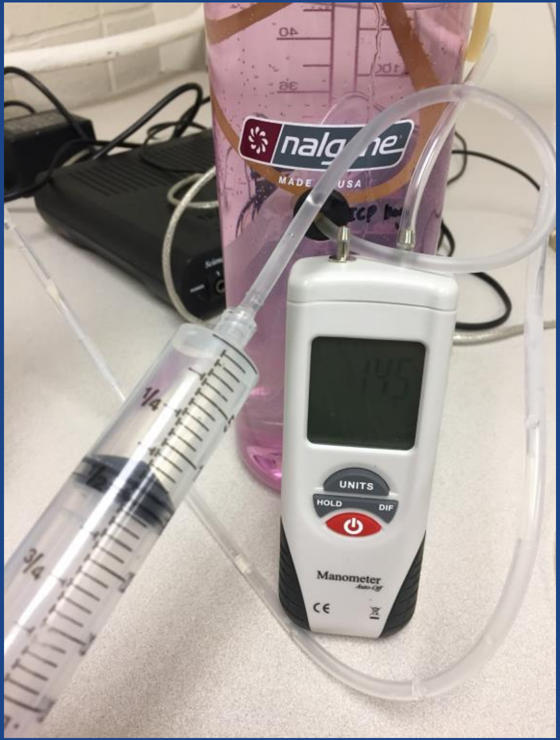
Mean Baseline Pressures of Flow Pump in Different States

State of Model	Mean Pressure (kPa)
Proximal Occluded	119.1
Proximal Unoccluded	103.4
Distal Occluded	97.7
Distal Unoccluded	101.8

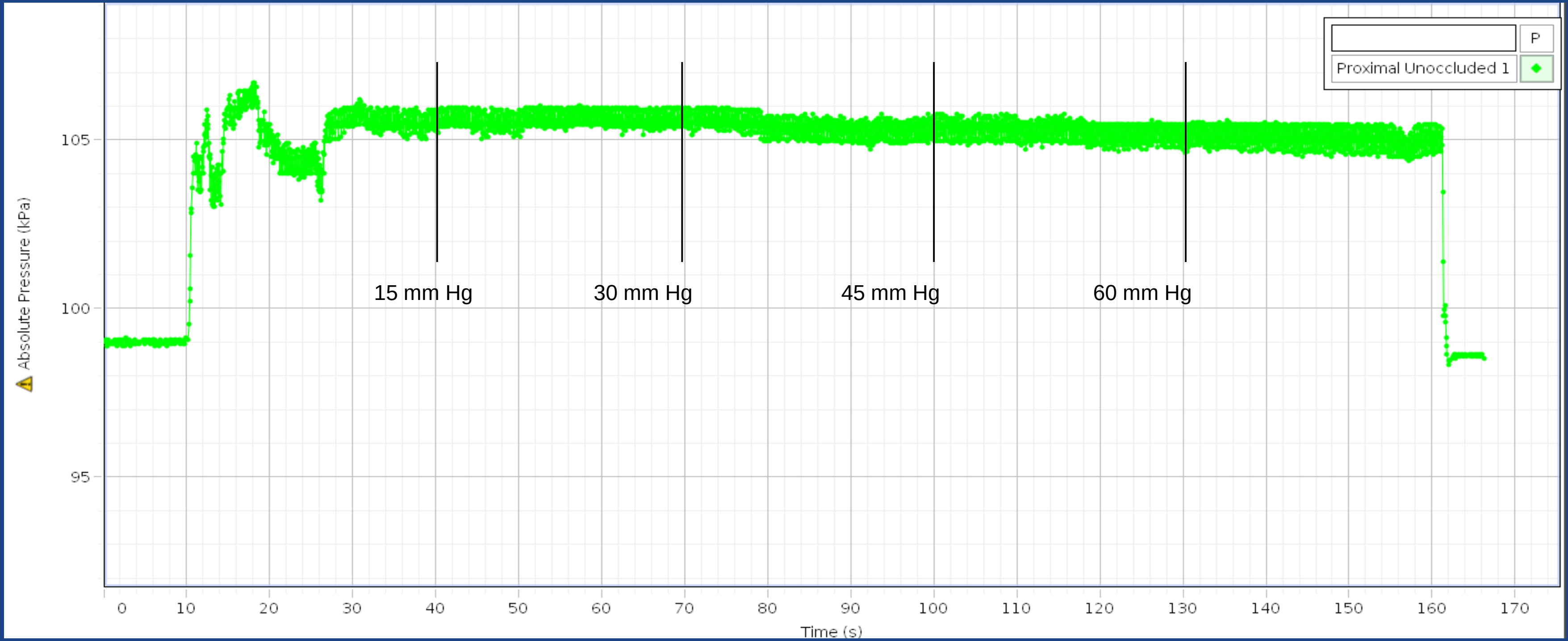
Pressure comparisons when the pump was turned on under an ICP of 0 mmHg



Pressures near the clot in relation to sequential increases in ICP



No significant relationship between low ICP increases and pressure proximal to the **unoccluded** MCA



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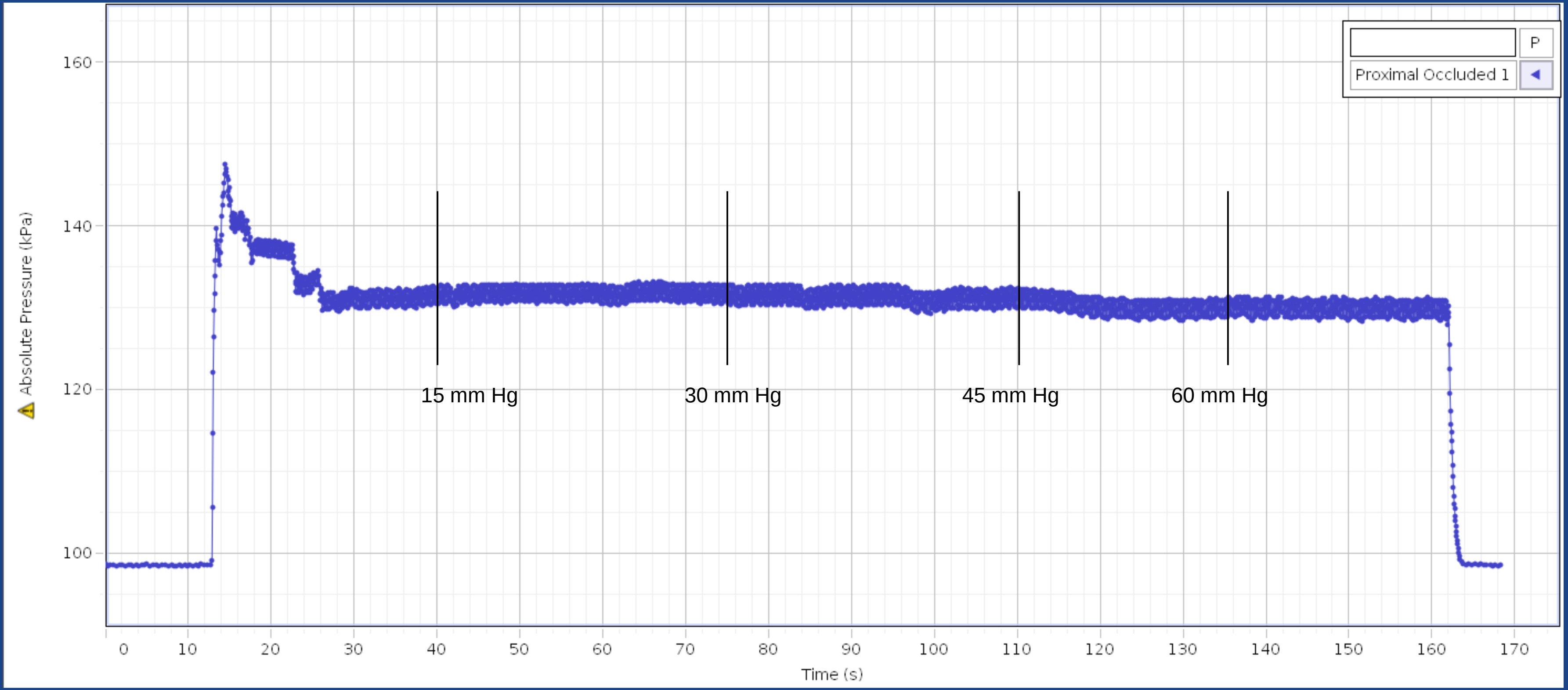
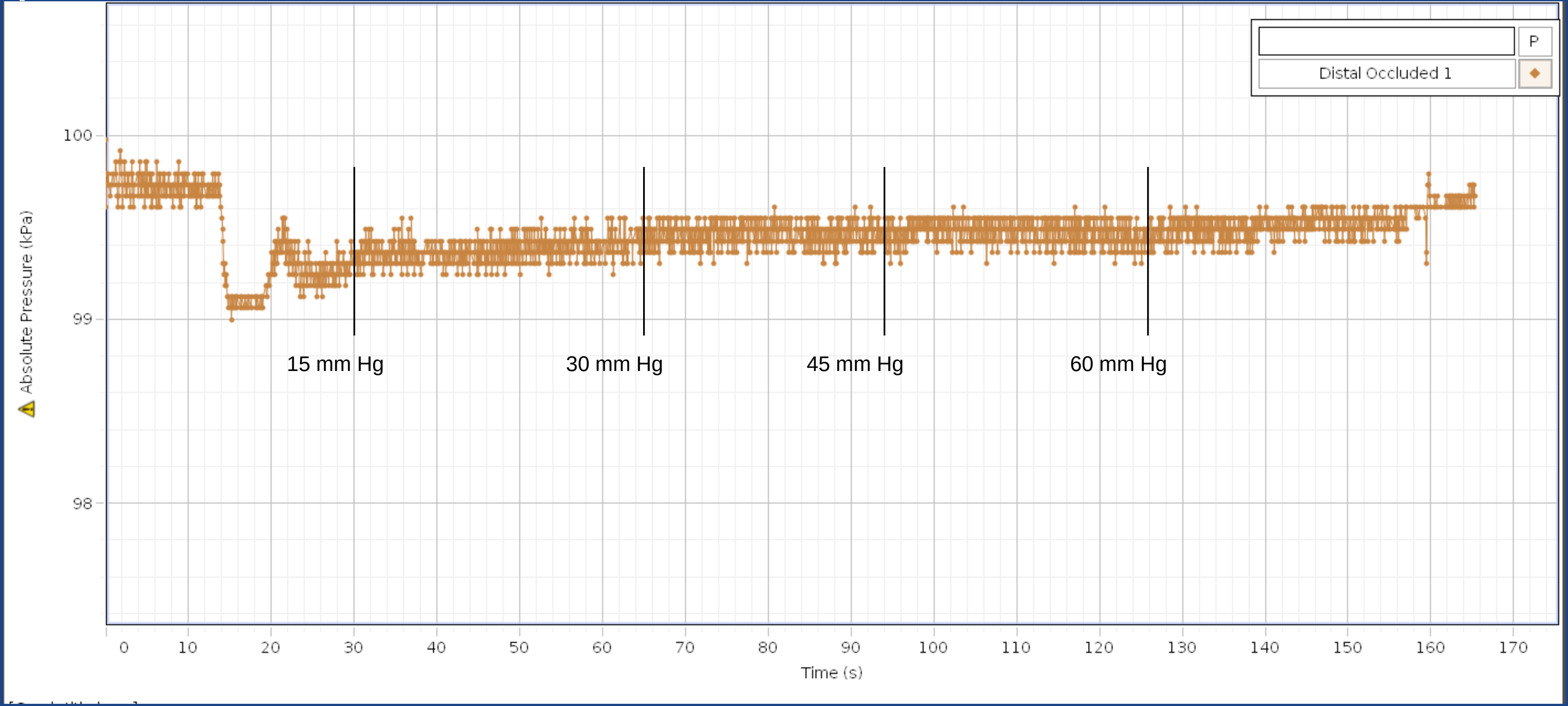


No significant relationship between low ICP increases and pressure distal to the **occluded** MCA



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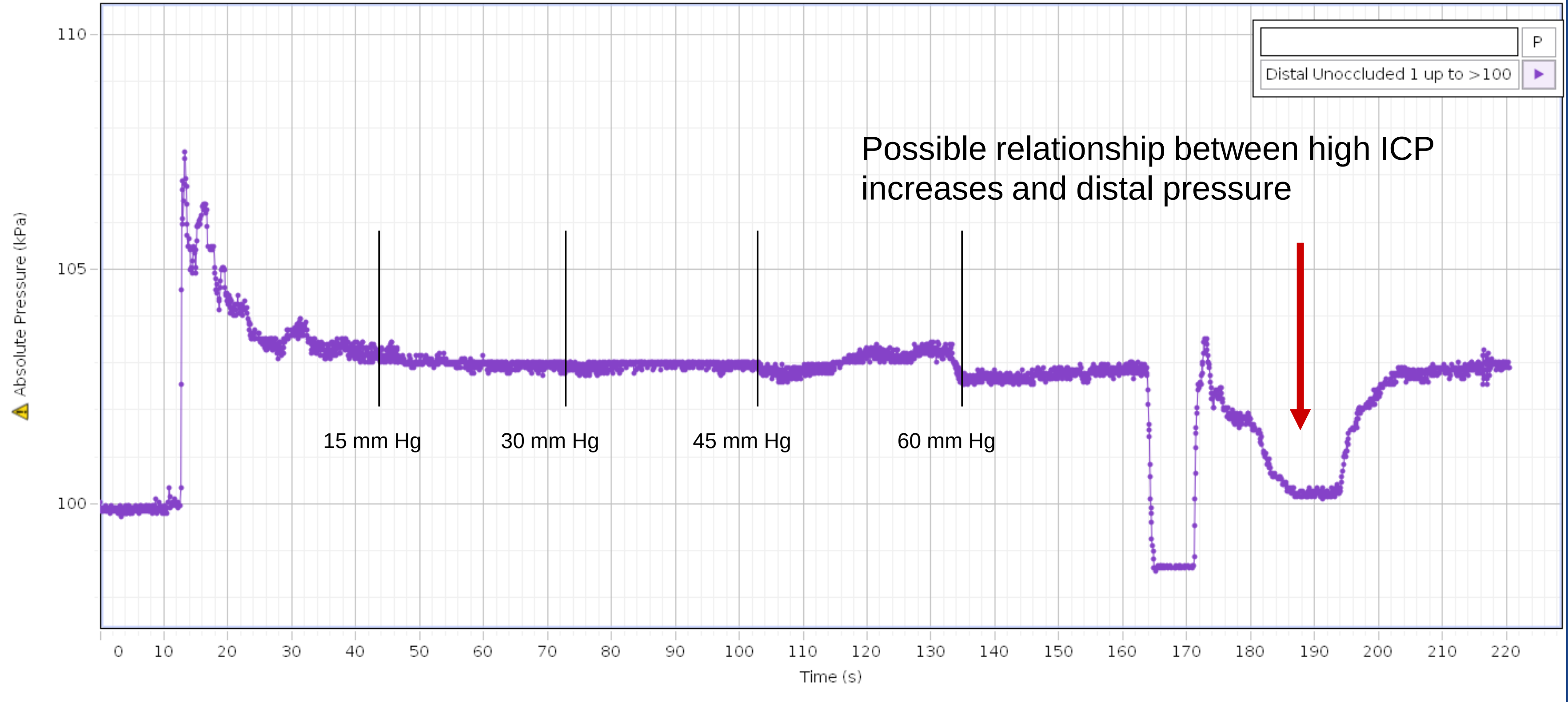
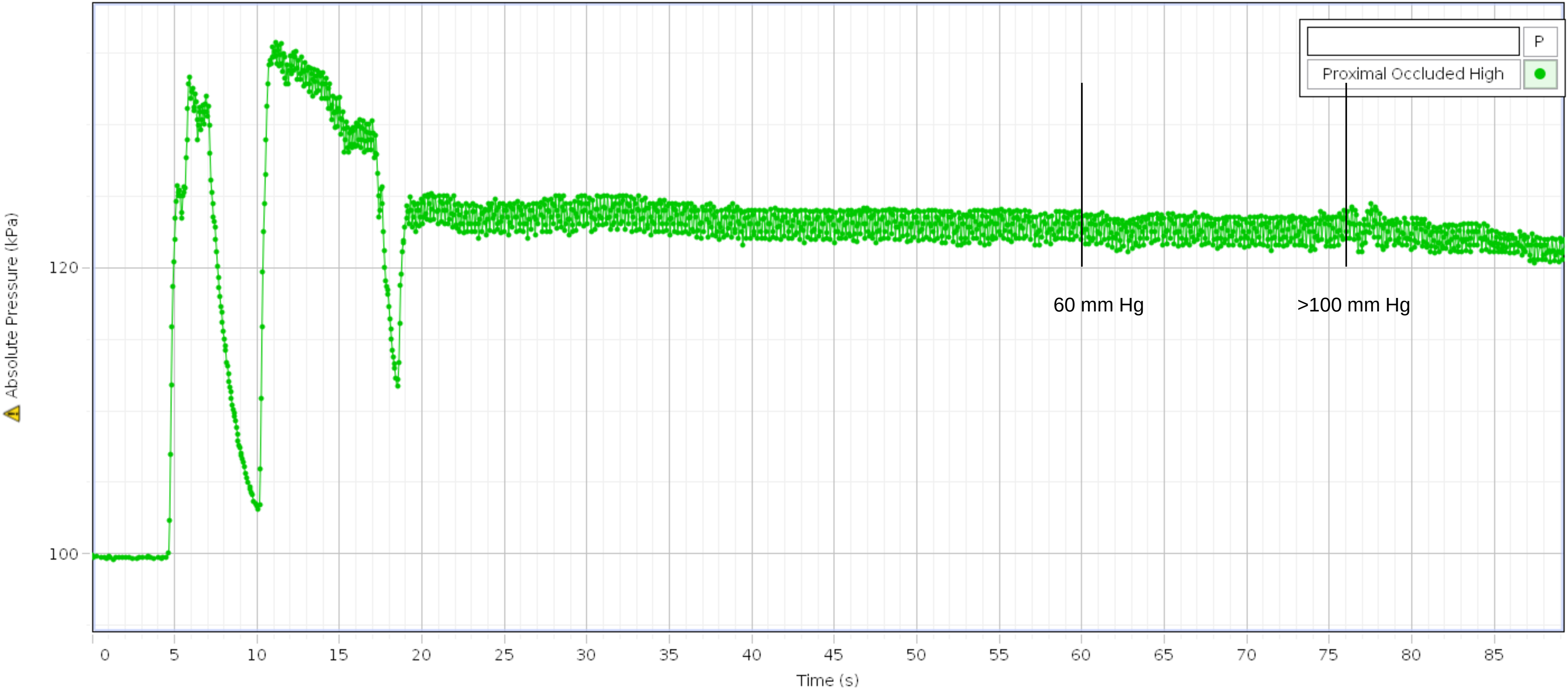
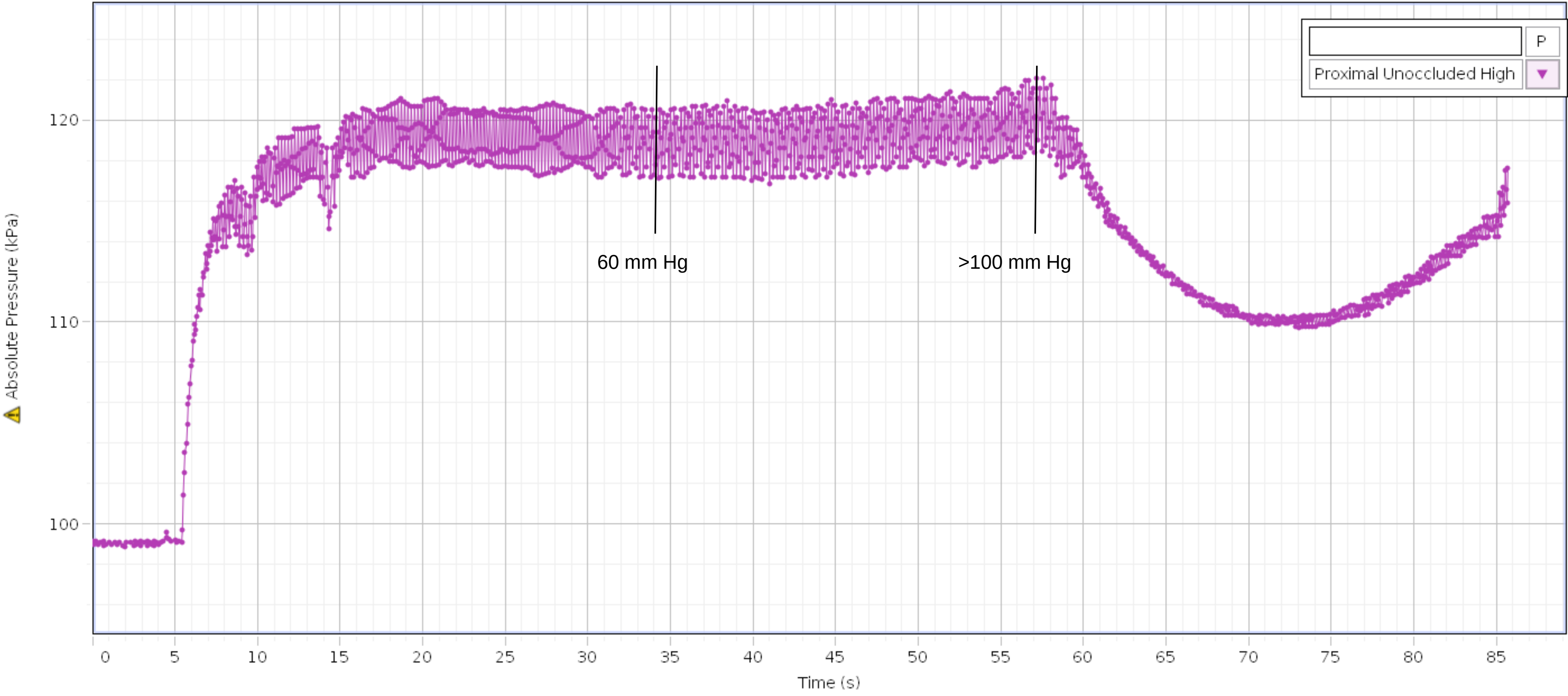


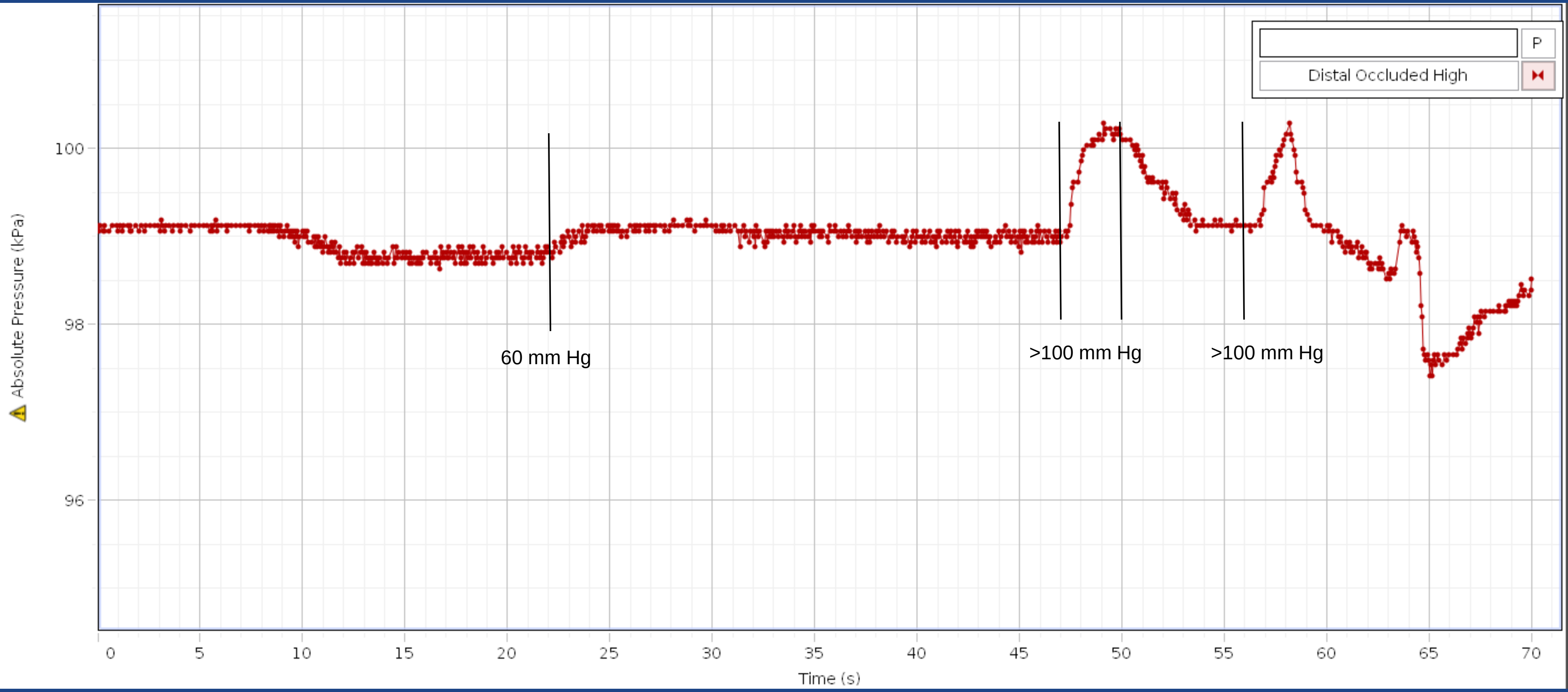
Relationship between pressure proximal to occlusion and unrecordable ICP.



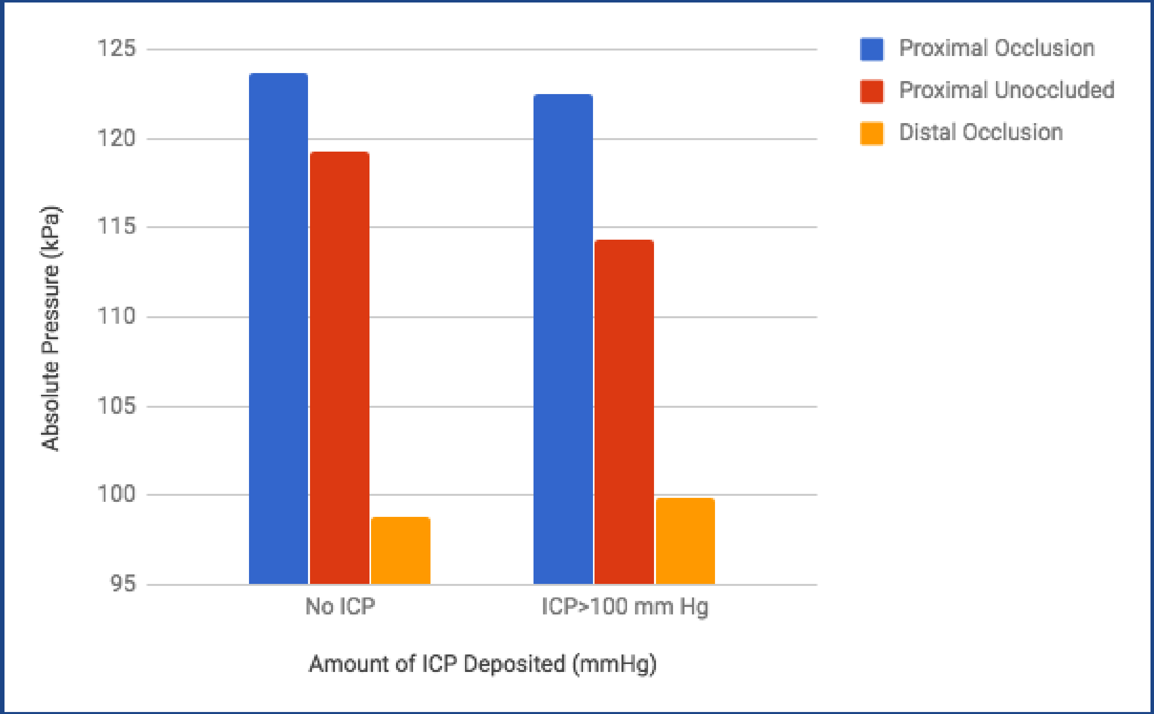
Relationship between pressure proximal to lack of occlusion and unrecordable ICP.



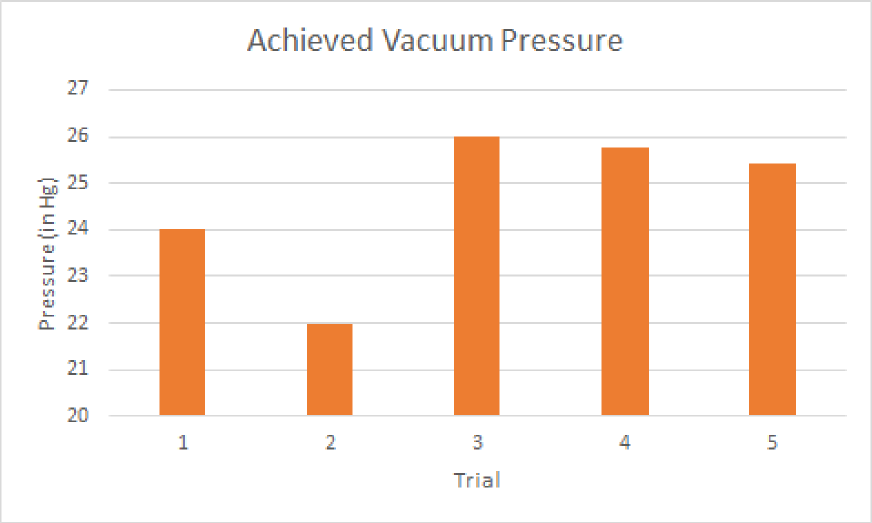
Relationship between pressure distal to occlusion and unrecordable ICP.

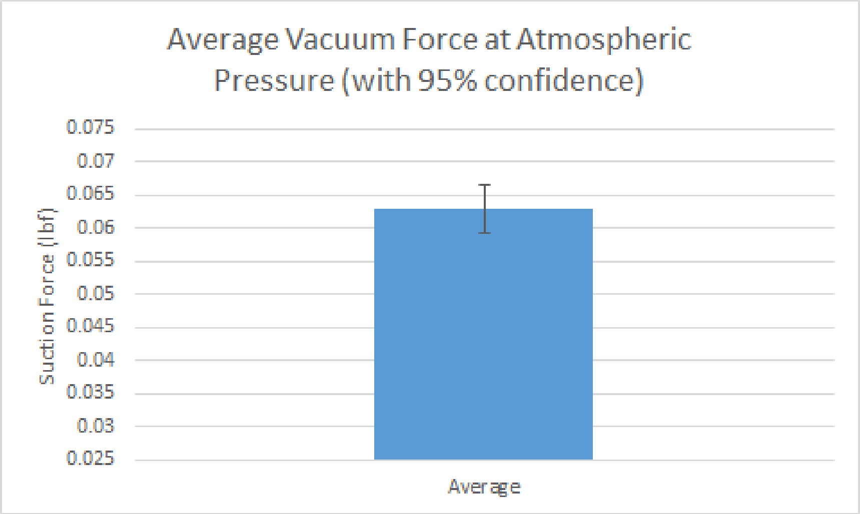


Average Pressures Recorded at Different ICP States



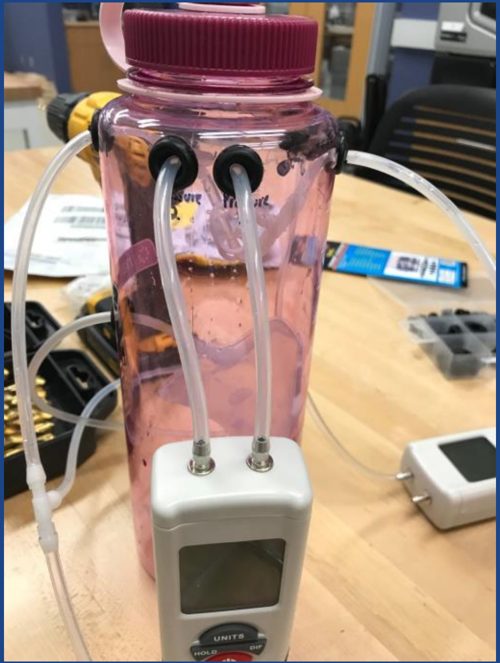
Atmospheric Suction Force Tests



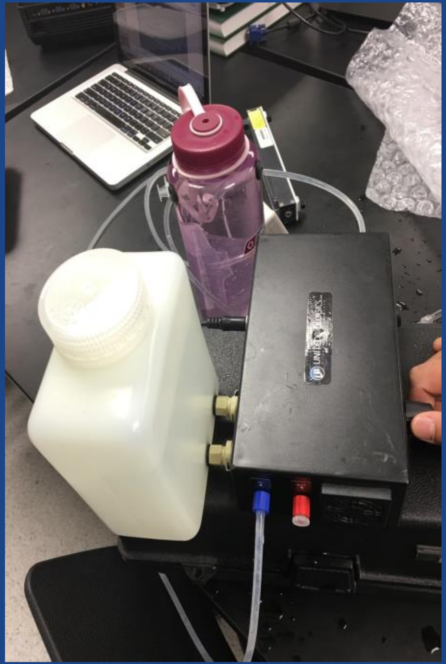


Current issues with pump tests

Single Pressure Gauge



Imprecise Flow Rate



Endeavors in the Making

- Necessity for electric, pulsatile pump
- Device to mimic clot in model
  - Must be easy to place, as well as easy to take out
- Methods to investigate effect of ICP on vacuum pressure
  - Inserting catheter tip into area of ICP control, then measuring negative pressure through rotating hemostatic valve.
- Looking for small strain gauge to measure catheter suction force
  - Run experiment measuring holding force under control and increased ICP conditions
  - Separation force measurements