The Thrombectomers: Update 6

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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.

Motivation behind our project

- Direct Aspiration Thrombectomy has the potential to replace stent-mediated removal of blood clots as the primary method of treating ischemic stroke.
- Decreases time in which the infarction causes localized brain death by 23 minutes

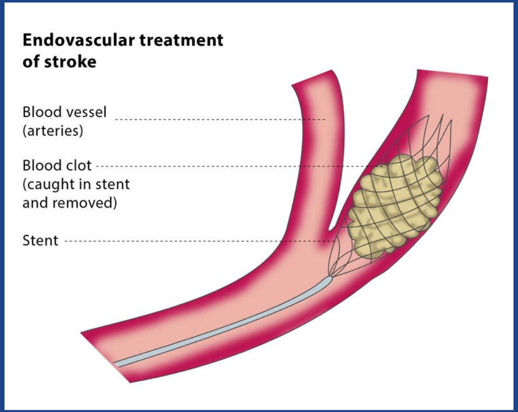
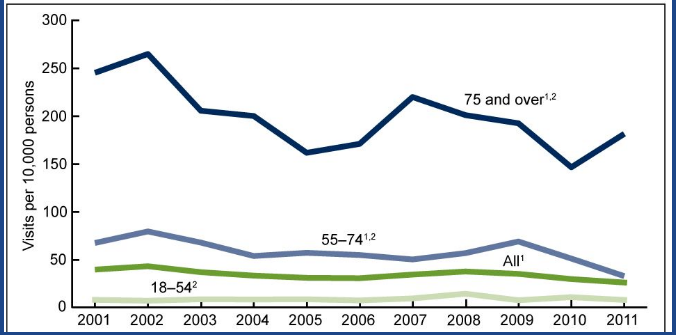
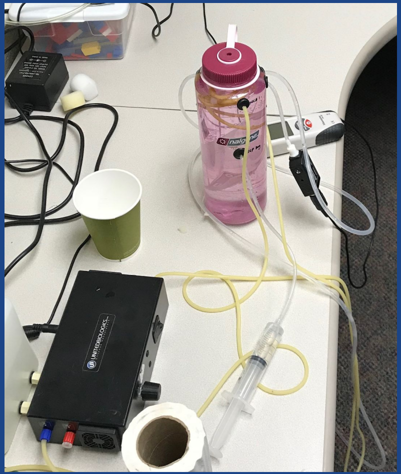


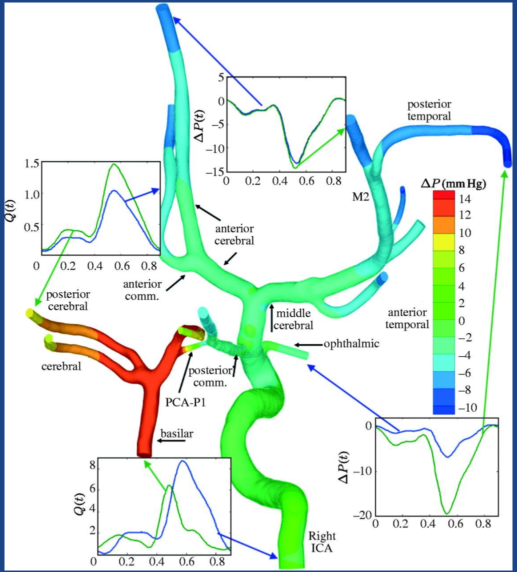
Figure 1. Age-adjusted and age-specific emergency department visit rates for ischemic stroke or transient ischemic attack among patients aged 18 and over: United States, 2001–2011



Our Theory

- Physical modelling, in contrast with current computational models, will allow us to vary parameters used in the surgery and find correlations that increase efficiency.



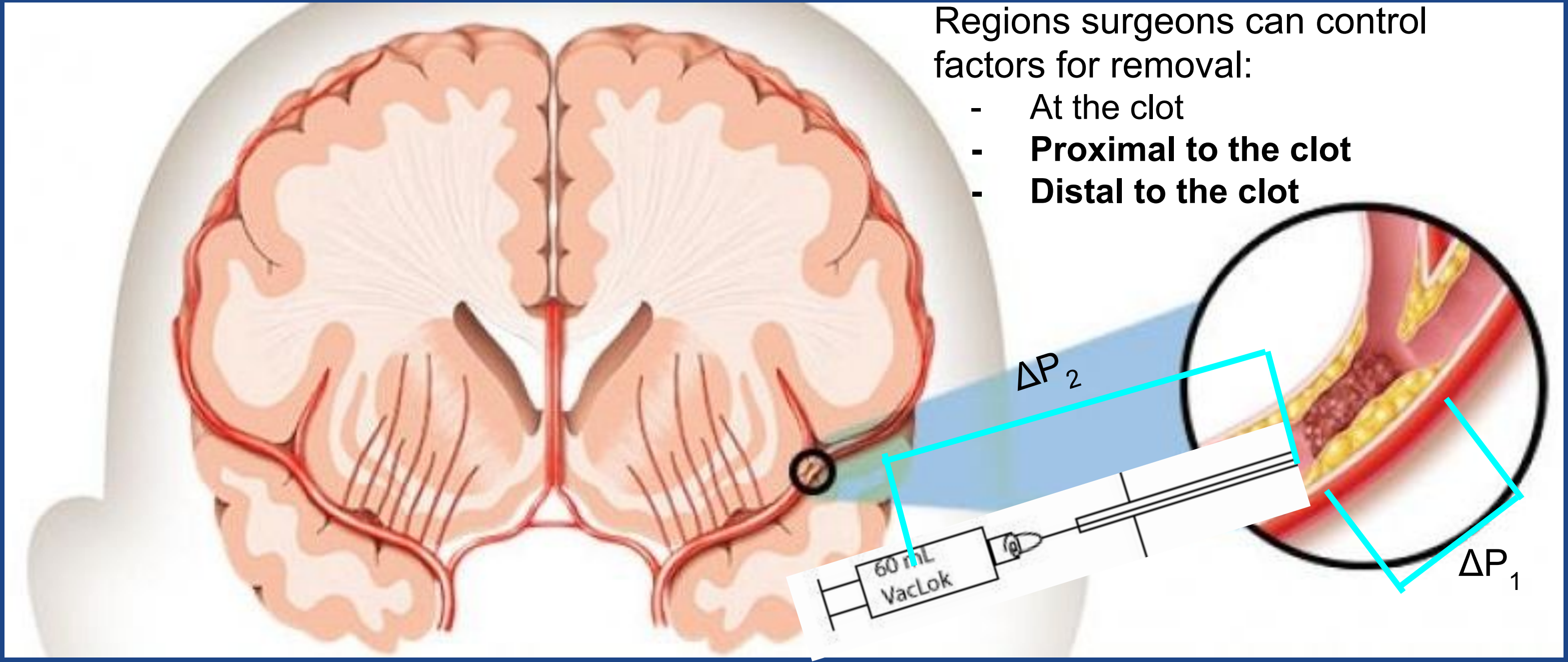


Theory: Physical modelling will allow for increased efficiency

- Increased ICP could decrease pressure gradient across the clot and increase suction force

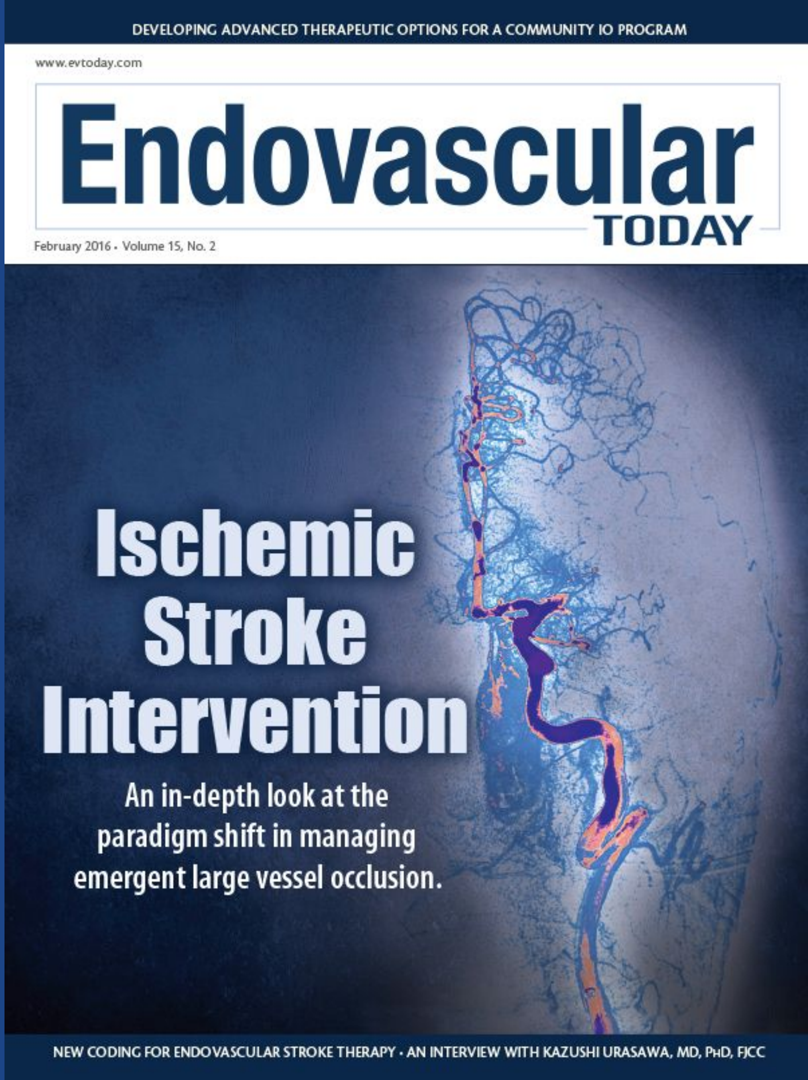
Regions surgeons can control factors for removal:

- At the clot
- **Proximal to the clot**
- **Distal to the clot**



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

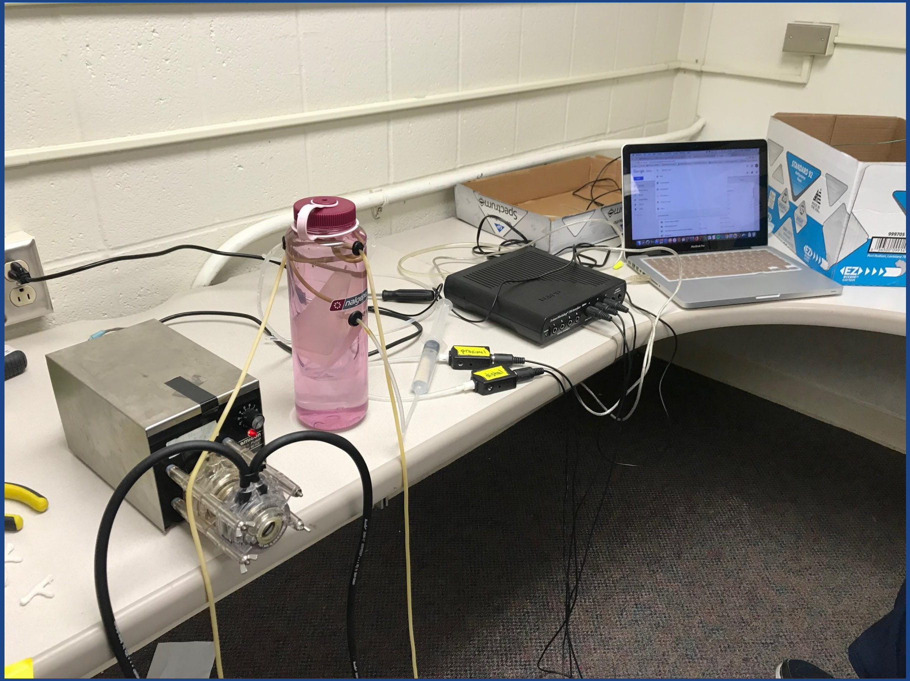


Gantt Chart

Task	Start Date	End Date	Timeline	Hours
Overall time period	9/26	4/23		
Time Period of work for this presentation	3/14	3/28		
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	3/31		12
Finalize model	3/5	3/31		10
Put together poster for Design Day	4/1	4/23		40
Present at Design Day	4/22	4/23		15

Model improvements since last presentation

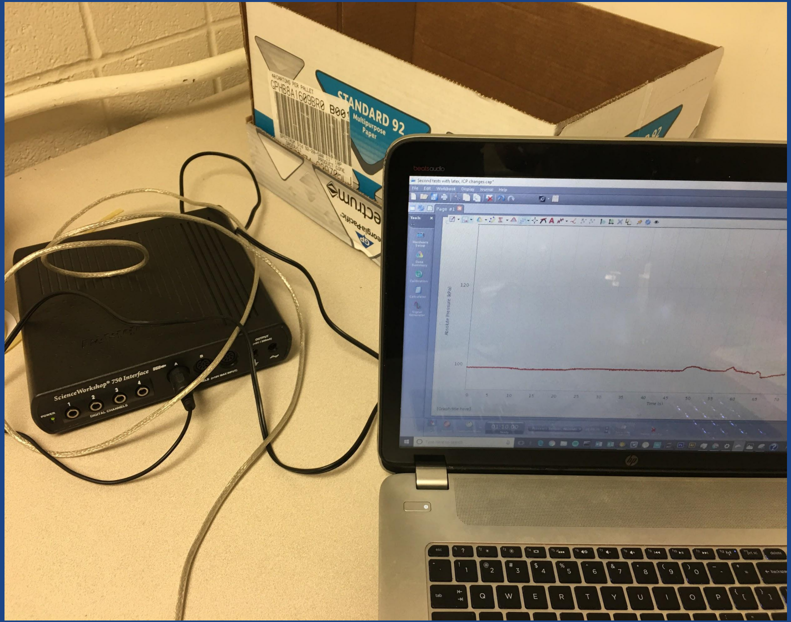
- Obtained new peristaltic pump
  - Borrowing from Dr. Merryman's lab
  - Produces consistent flow rate - can tune to physiological flow (~100 ml/min)
  - Produced way too much pressure when occluded
- Obtained multiple digital pressure gauges
  - Borrowed from Dr. Charnock in the physics lab
  - 20 Hz sampling rate, directly outputs to an industry standard software application
  - Can now measure ICP, proximal and distal MCA pressures simultaneously, continuously, and accurately



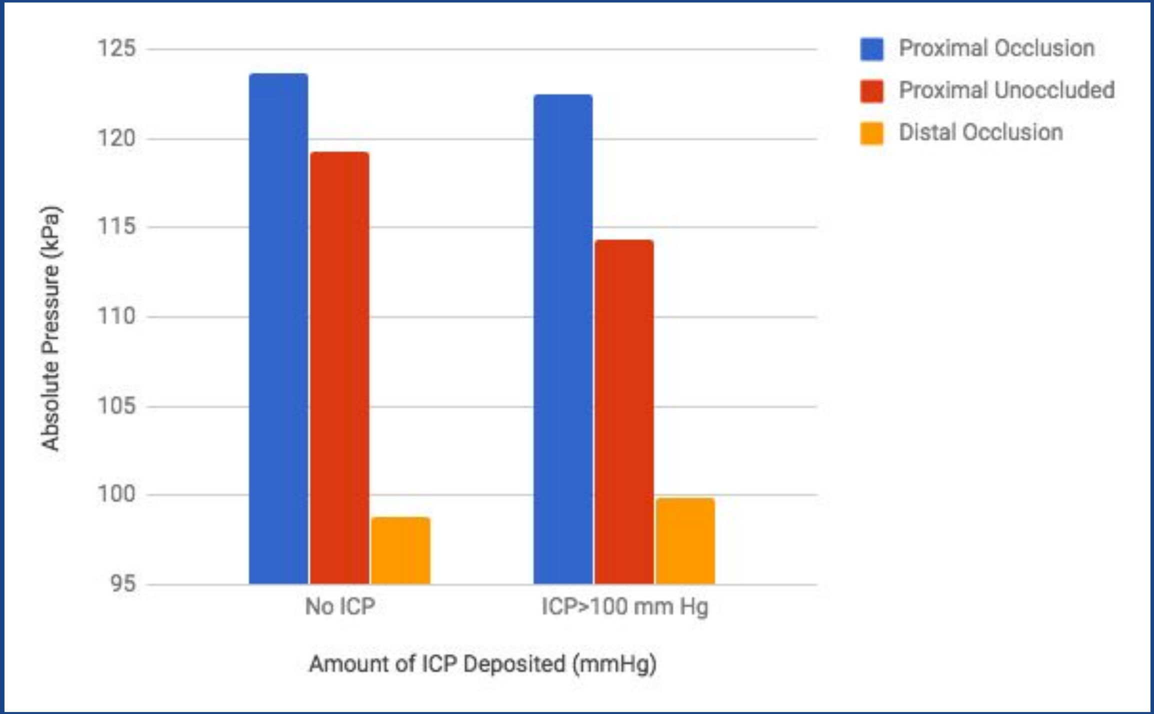
Accomplishments

- Measured pressures under flow
  - Had issues when occluded
  - Increases in ICP had little effect on proximal and distal pressures unless ICP was elevated above physiologic levels
- Performed suction force tests
  - Determined that ear plug material is too porous to maintain a vacuum.
  - Created method of measuring suction force.

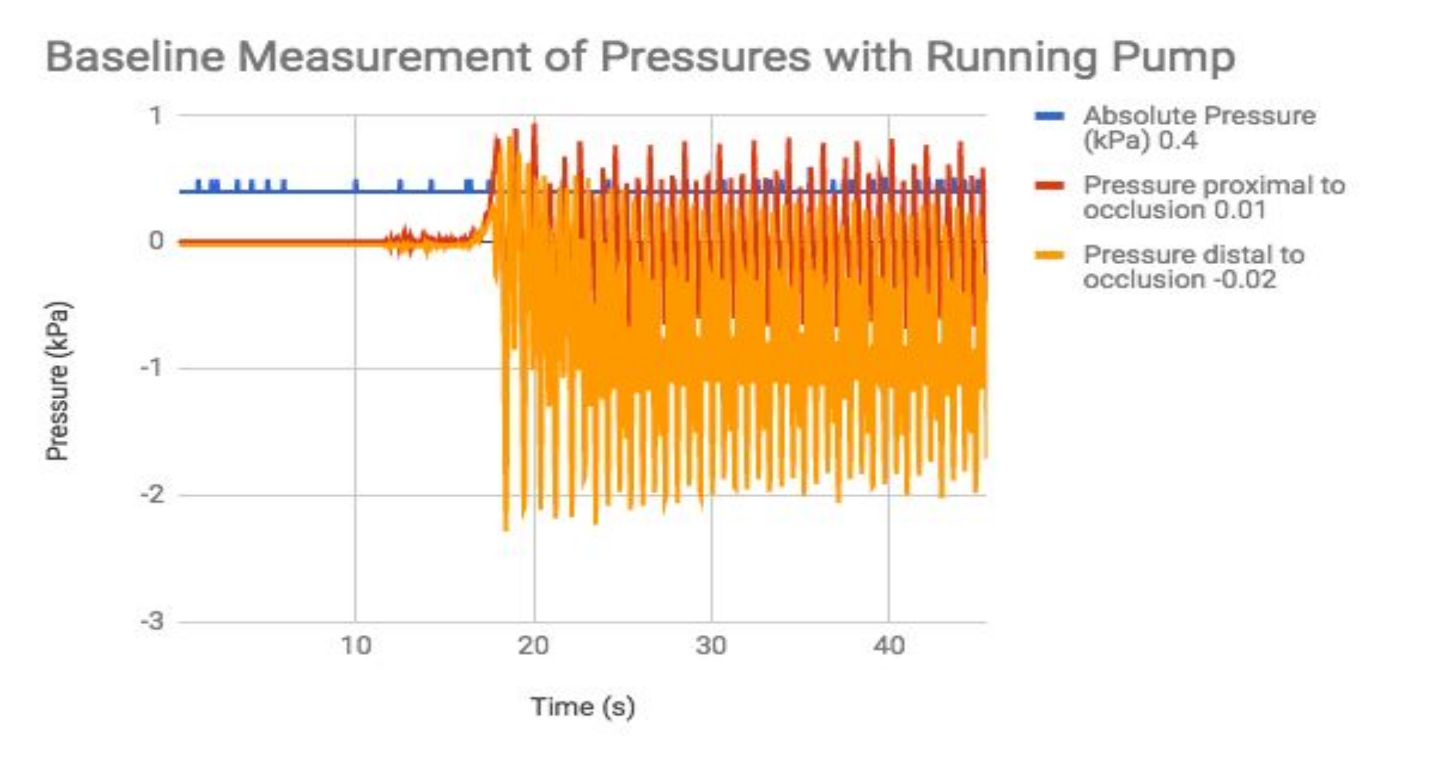
Initial Tests with Continuous Pressure Gauge



Average Pressures Recorded at Different ICP States



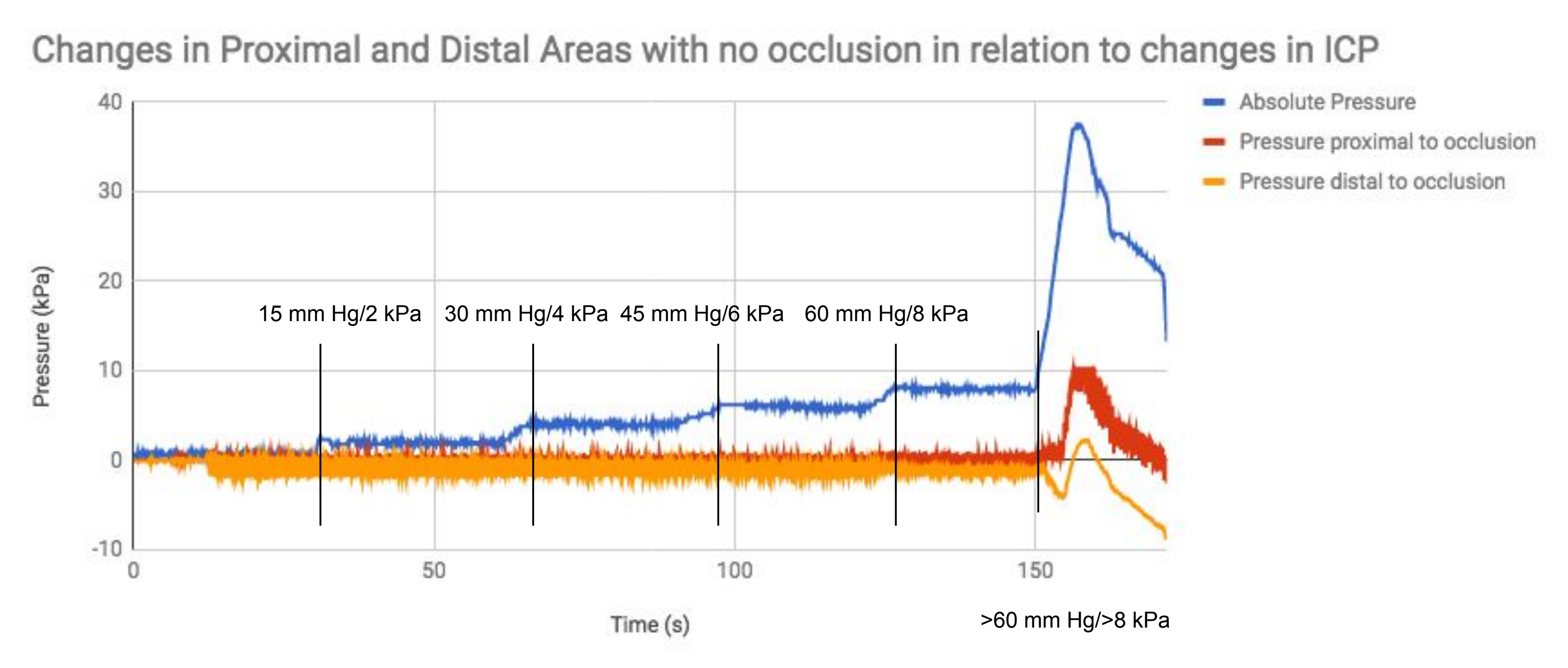
Pressure comparisons when the pump was turned on under an ICP of 0 mmHg



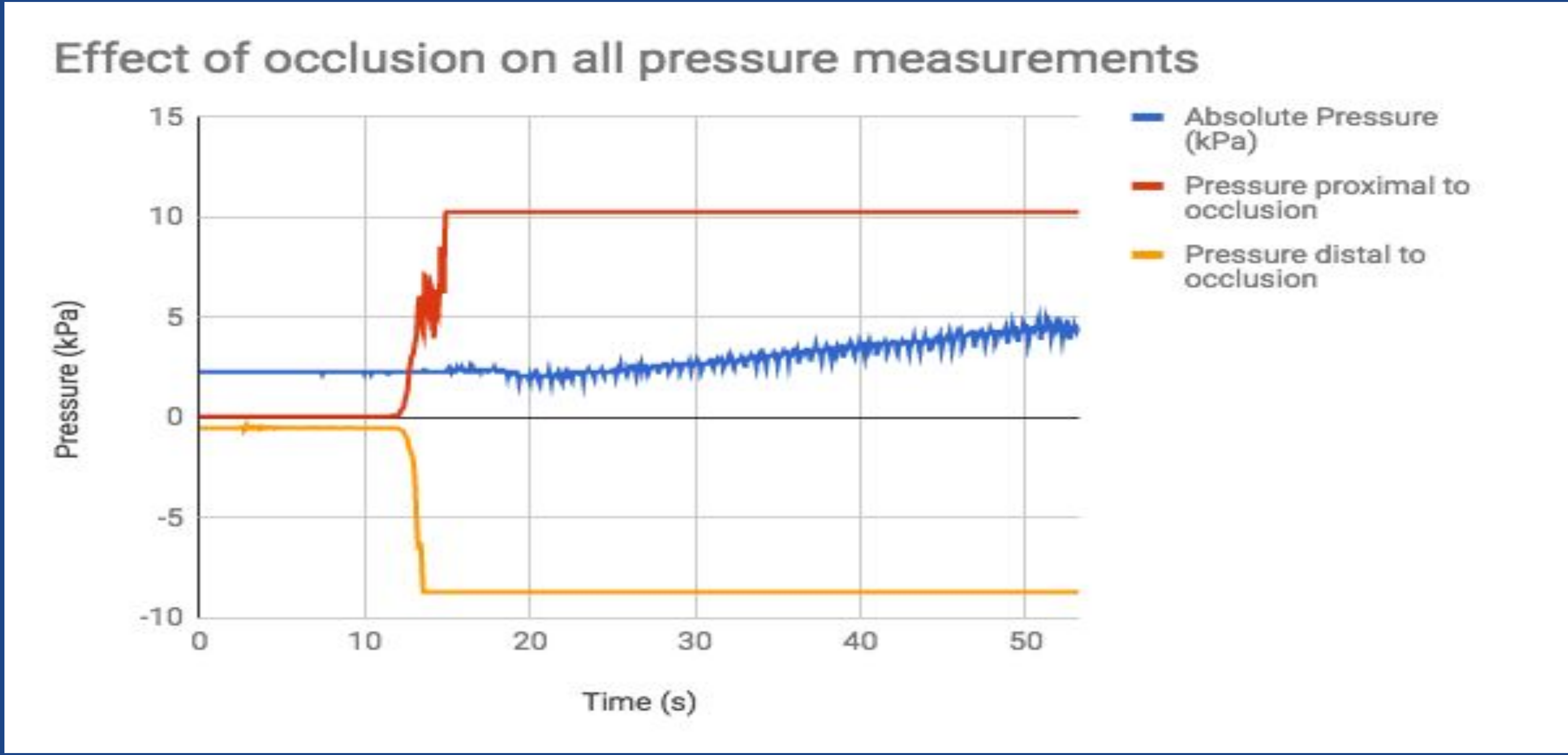
Mean Baseline Pressures of Flow Pump in Different States

State of Model	Mean Pressure (kPa)
Absolute Pressure	0.405
Proximal Unoccluded	0.024
Distal Unoccluded	-0.453

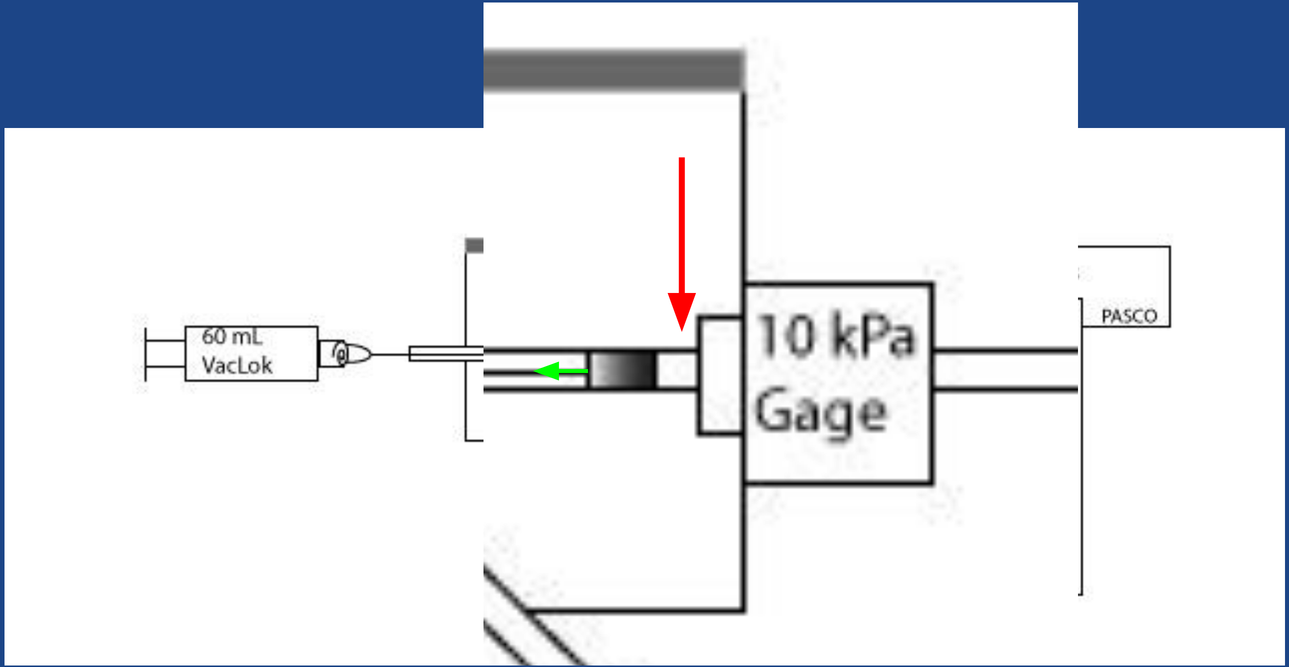
No significant relationship between low ICP increases and proximal and distal pressure to the **unoccluded** MCA



Strength of occlusion on ICP and proximal and distal pressures



Catheter Suction Force Configuration



Endeavors in the Making

- Device to mimic clot in model
  - Must be easy to place, as well as easy to take out
  - Foam and earplugs were unsuccessful
- 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
- Method to avoid extreme vessel distension
  - New pump is too powerful
  - Adding a vessel parallel to clot