The (Dr. Matthew) Walker Texas Rangers III
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Revised project objective statement: Develop a smart-shunt design for hydrocephalus treatment which detects proximal failure through measurement of differential pressure between the shunt and the brain and communicates this failure via near field communication to a smartphone external to the body.

Achievements since last report: We have finalized our design and successfully constructed a CAD model for it. We will be using a strain gauge embedded in a PDMS window in the shunt tip in order to detect the differential pressure. As our design requires obstructing 4 holes at the tip of the shunt, we tested whether there were any significant changes in flow rate due to fewer holes. We obstructed holes using parafilm and tested the flow rate of saline+albumin (CSF phantom) through the strain gauge with 24, 18, 12, 3 and 0 open holes. We observed no significant change in the flow rate from 24 to 12 holes, which suggests that obstructing 4 holes will not hinder shunt function. For the PDMS window, we acquired elastomer and curing agent and cured three different types of PDMS with increasing stiffness. Lastly, since the product sheet of the strain gauges does not include the relation of strain gauge resistance to pressure, we have to do the calibration ourselves before we can move further, for which we have designed an experiment. We constructed a water column by drilling a hole in a pipette, and a glass stage which will hold the strain gauge + PDMS inside the pipette through that hole such that the strain gauge is perpendicular to the water pressure.

Problems that have arisen: We originally obtained strain gauges from Vishay Precision Group. However, these were not encapsulated, making them impossible to use in aqueous testing. Vishay was also out of stock of the bridge completion module required to complete the circuit. Therefore, we had to order more strain gauges and bridge completion modules from Omega Engineering, creating a slight delay. The new strain gauges were received on March 23, 2017. The second issue has been acquiring the proximal shunt tubing to build prototypes. We have only one sample that Dr. Feldman acquired for us, and the tubing is not available commercially. However, we are now hoping to receive at least five more from Dr. Feldman within a week.

The NFC shield has not yet been tested due to a delay in a voltage level shifter. The level shifter is needed to use the shield with the SPI arrangement on the Arduino, so no testing has yet been done. Skeleton code has been written for the Arduino, however, which means only a simple wiring setup needs to be done to test the NFC portion.

Work that lies ahead: The most important task ahead of us, now that we have received the correct strain gauge, is to construct the whole circuit and calibrate the strain gauge resistance to the applied pressure, using the water column. We will insert the strain gauge into the column and change the water height (corresponding to known pressure, P=rho*h*g), measure the resistance in the gauge and calibrate it to pressure. Once we have this information, we will start building our prototype. We will have to figure out how to cut a precise window in the shunt tubing and how to seal the PDMS/strain gauge window into this hole. We will then test different shunts, with the window at different positions within 3 cm of the tip, for failure detection. Failure will be simulated by clogging the holes of shunt using parafilm, and we will use a similar set-up as the one in the flow experiment. Ideally, the strain gauge will be able to detect that there is no flow by detecting the differential pressure between the saline+albumin column and the shunt lumen.

Assessment of meeting schedule: We believe we will be able to design a prototype for proof of concept by design day. While we do not have the tools or skills to embed the wiring and circuitry inside the shunt, we should still be able to show that the strain gauge can (hopefully) detect the differential pressure that arises due to simulated proximal failure.