BTK Inhibitor Implant for the Prevention of Anaphylaxis

Lexie Brehmer, Trayce Borms, Solomon Baez, Hanna Hansen

BACKGROUND

Problem:
16 million people experience anaphylaxis per year[1].

Current solution:

- epinephrine auto injector with approximately 3.6 million patient prescriptions annually[2].
- Epinephrine auto injectors must be replaced every 12-18 months, are non-reusable, and must always be carried
- The person administering epinephrine is generally not the person experiencing anaphylactic shock[3][4].

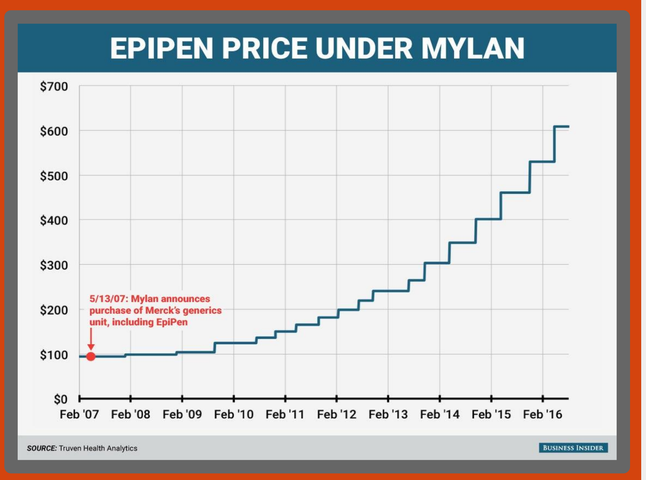

Figure 1 - Epipen 600% Price increase over a 10 year period Courtesy of Business Insider

OBJECTIVE

The BTK inhibitor implant eliminates stressful, expensive, life threatening situations involving anaphylactic shock. BTK inhibitor implants will be more efficient, safer, and less expensive than epinephrine injections. Thus, while traditional methods used during a severe allergic reaction treat anaphylactic shock, the BTK inhibitor implant prevents anaphylaxis from occurring at all.

Method

COMSOL models:

- Implant dimensions
- polymer diffusion parameters
- refilling schedule.

SOLIDWORKS model:

- Final shape
- Stress testing
- Inner dimensions

Final Product

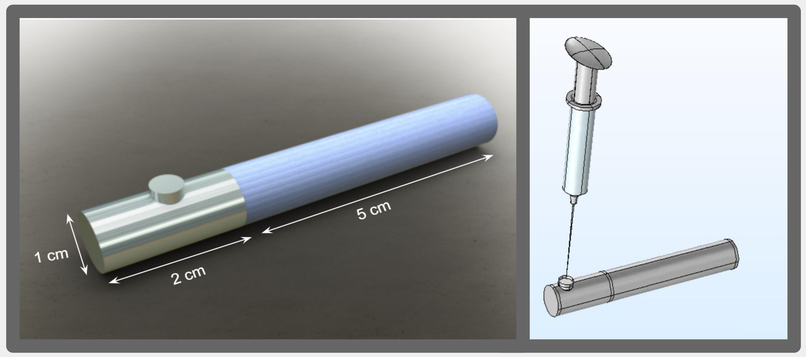

Figure 2- Final Solidworks model of the Refillable BTK Inhibitor Implant.

RESULTS

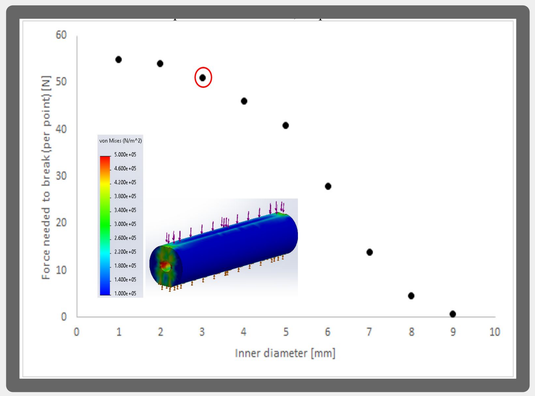

Figure 3- Results from Solidworks stress testing showing the effect of inner diameter on the force needed to break the implant. *Inset:* maximum force distribution applied before breaking for an inner diameter of 3 mm (red circle).

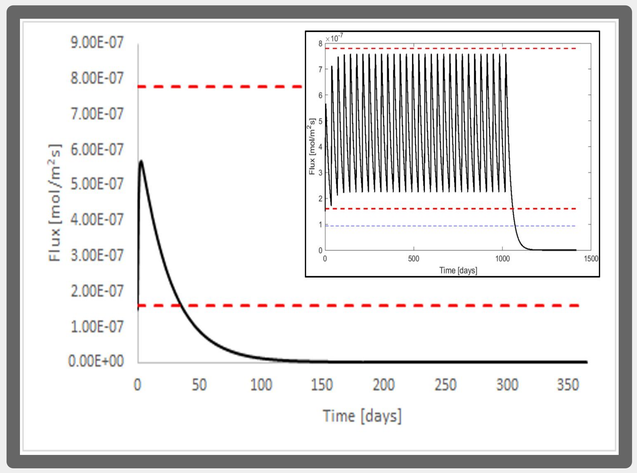

Figure 4 - Flux of ibrutinib from the implant into the surrounding tissue. *Inset*: flux when refilled every 35 days. Red dashed lines are upper and lower fluxes for desired dose, and blue line is the minimum flux for partial protection against anaphylaxis

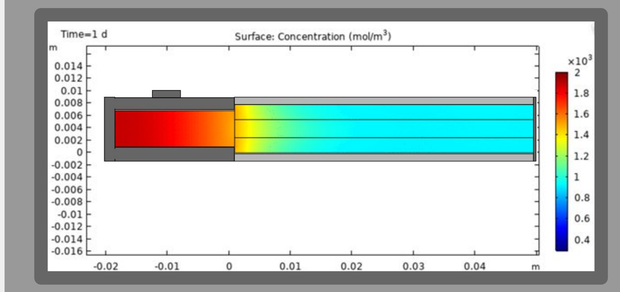

Figure 5- COMSOL model of implant 1 day after refill. The inner polymer reaches radial equilibrium with refill cavity at the center.

DESIGN JUSTIFICATION

- A refill schedule of every 35 days ensured that flux is within the desired boundaries for 95% BTK occupancy (Figure 4).
- Inner polymer layer of implant refills faster than drug leaves the implant (Figure 6).
- The implant can withstand a maximum von Mises stress of about $6x10^5$ N/m², and an inner diameter of 3 mm provided an adequate refill volume without compromising structural integrity (Figure 3).
- Materials are biocompatible and non-degradable for long lifetime.

SUMMARY

- Implant placed in the thigh
- $400 initial cost
  - $100 sliding scale annual refill cost
- 35 day implant viability before refill
  - refill done at home or at clinic
- Anaphylaxis is prevented and no epipen is needed

ACKNOWLEDGEMENTS

Special Thanks to the College of Engineering, Oregon State University for the funding of this research project. Additional thanks to Dr. Adam Higgins, Dr. Patrick Goeghegan, and Ramila Gulieva.

SOURCES

[1]Turner, P., Jerschow, E., Umasunthar, T., Lin, R., Campbell, D., & Boyle, R. (2017, September 06).
[2]Swetlitz, I. (2016, July 06).
[3]Simons, F., Edwards, E., Read, E., Clark, S., & Liebelt, E. (2010, February).
[4]Brown, J., Tuuri, R., Akhter, S., Guerra, L., Goodman, I., Myers, S., . . . Park, E. (2015, October 09).