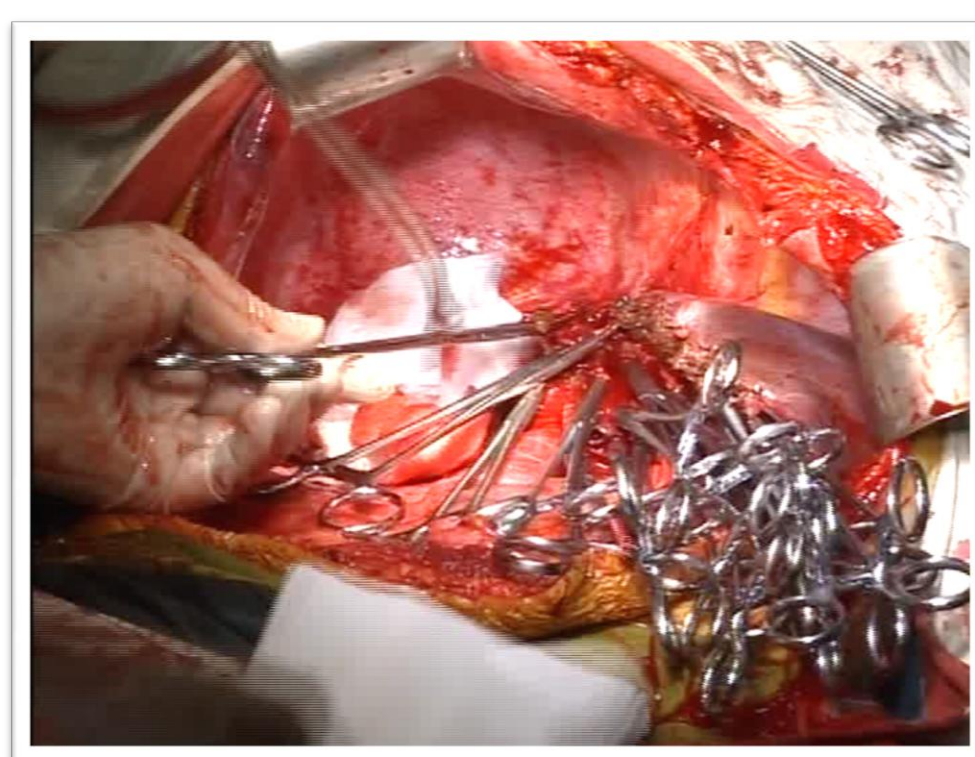


## Abstract

Excessive bleeding is the most common complication of liver resection. Currently, no low-cost devices exist that reduce blood loss during resection while minimizing residual tissue damage, increasing speed of the procedure, and sealing bile ducts. We have designed such a device, the SutureTie, a purely mechanical apparatus that allows surgeons to insert resorbable zip-tie sutures into the liver parenchyma to obstruct local blood flow prior to manual transection. A proof-of-concept prototype has been tested successfully on a perfused, ex vivo porcine model.

## Problem

- Excessive bleeding during liver resection procedures leads to increased rates of perioperative and postoperative morbidity
- The Pringle maneuver, used to block blood inflow to the liver during resection, can only be applied for 15-20 minutes at a time to avoid hypoxia, making longer procedures problematic
- Current devices on the market have a number of drawbacks including
  - Excessive residual tissue damage
  - Slow transection speed
  - Inability to seal bile ducts
  - Excessive fluid influx
  - Prohibitively high cost



Many Kelly clamps are seen here occluding the blood flow from the transection plane of the liver. This method is generally called "clamp-and-crush." This method, though highly manual and skill-intensive, is still the most widely used for liver surgery around the world, primarily because of its speed, low-cost, and proven effectiveness.

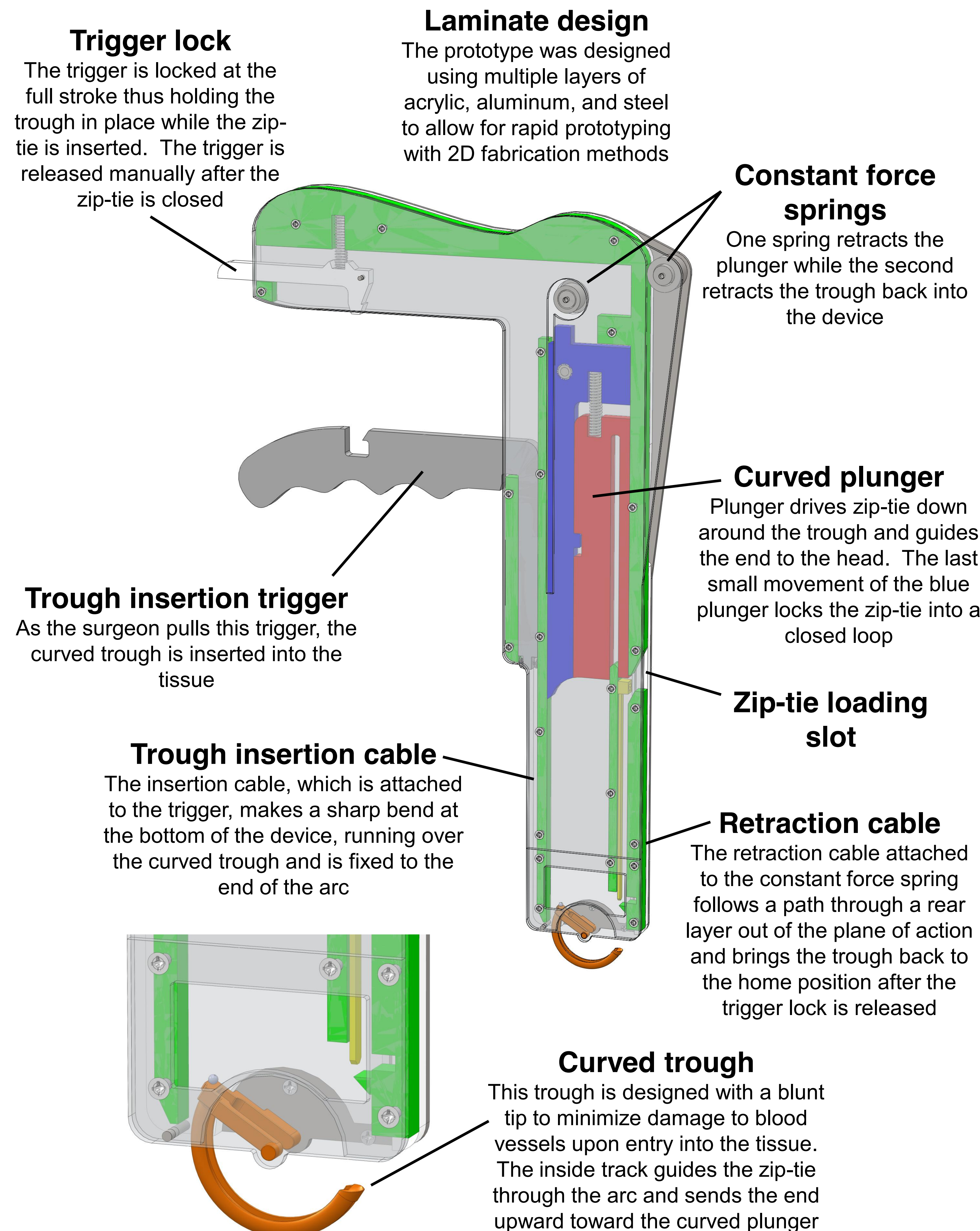
## Objectives

Design a device that,

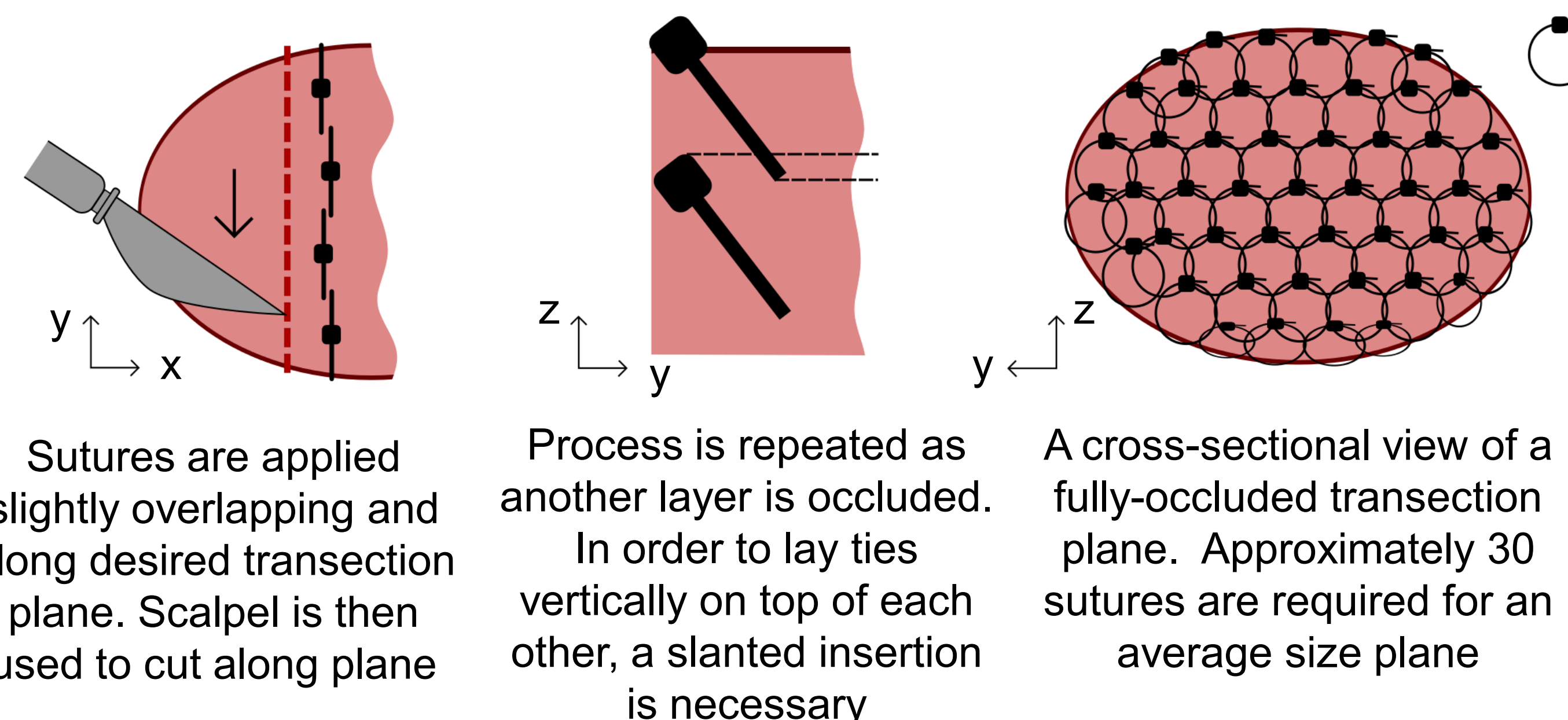
- Minimizes blood loss
- Minimizes residual tissue damage
- Occludes both blood vessels and bile ducts
- Does not increase surgical time
- Does not increase risk to patient
- Is relatively low cost
- Can be widely adoptable, even internationally

## Acknowledgements

We would like to thank Dr. Jiping Wang, Nikolai Begg, Professor Alex Slocum, Nevan Hanumara, and Dave Custer for their advice and instruction throughout the project.



## Time series showing trough insertion and zip-tie closure

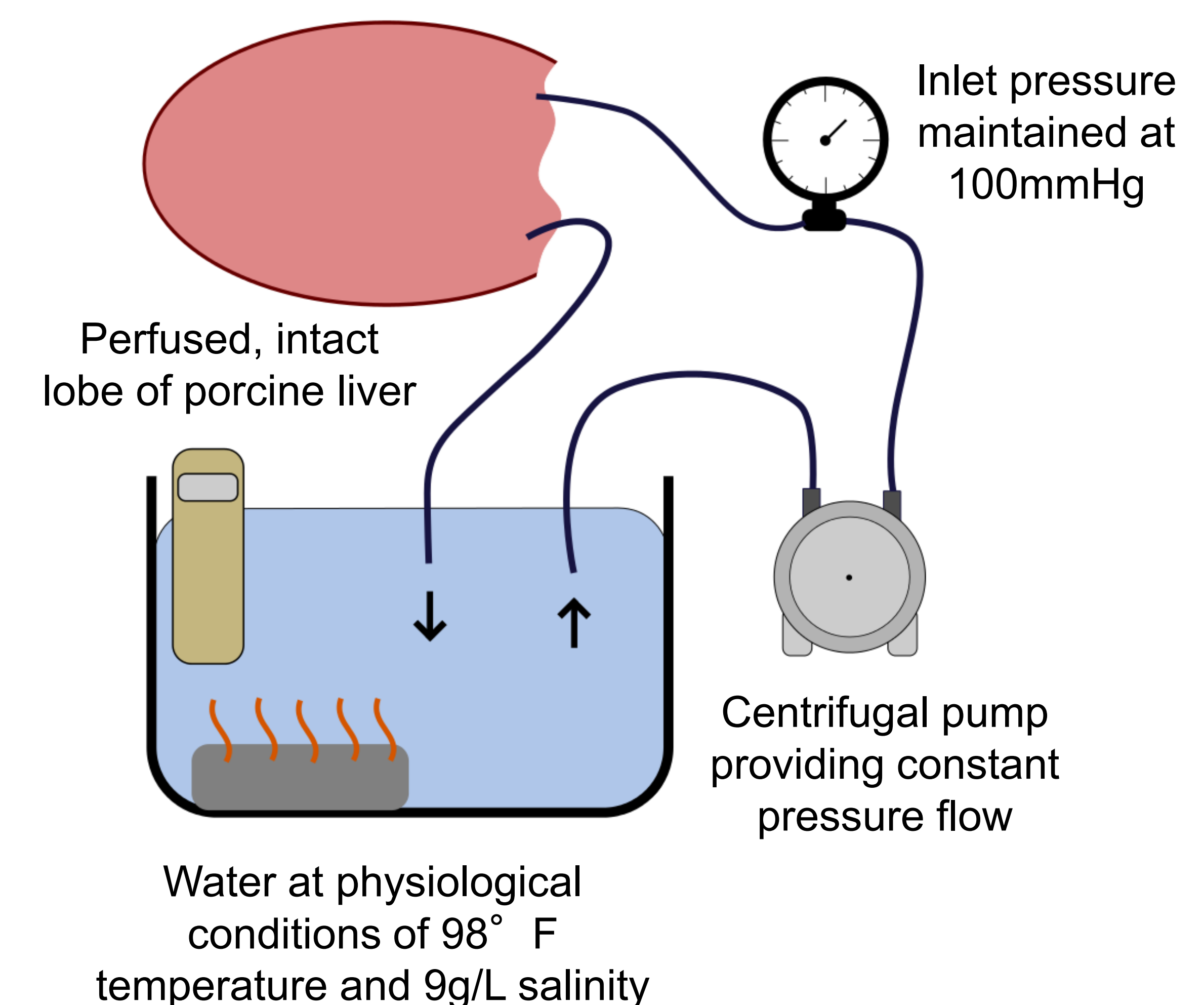


## Evaluation

Several calculations were performed to ensure the feasibility of this design:

- Manual actuation forces are in ergonomic range
  - 13.2N to insert trough and puncture liver
  - 3.34 N to actuate plunger and close zip-tie
- Trough stress factor of safety of 4
  - FEA analysis shows maximum stress of 55 MPa
- Suture tensioning required 43.5 N, easily provided by hand

Additionally, the proof-of-concept was tested on an ex-vivo experimental setup as depicted below



## Future Work

- One-handed operation
- Suture cartridge for quick loading of subsequent zip-ties automatically
- Suture tensioning mechanism to avoid the manual step of zip-tie tightening
- Added surgical blade to automatically make incision next to the occluded plane
- Testing on in-vivo porcine model to verify minimized bleeding

