Product Design Specification
Trans-arterial chemo-embolization simulator (liver phantom)

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Project Background:

Liver cancer treatment can often involve higher, more targeted doses of chemotherapy if delivered directly to the liver. Professor Block's lab is integrating capabilities to guide cancer treatment to the liver using magnetic resonance imaging. Current x-ray treatments significantly over treat the patient's liver because radiologists and other clinicians cannot visualize the tumor. The lab is in need of a simulator (phantom) that will simulate the arterial vessels of the abdominal and liver so they can simulate treatments and train interventional radiologists on using the new MRI guidance techniques. The project will include adding flow capabilities using a flow pump to simulate pulsatile flow. Flexibility exists in how realistic the vascular network has to be. In addition opportunities exist to work with scientists and interventional radiologists after the semester is complete.

Terminology:

Superior	Towards the head with respect to the transverse plane
Inferior	Towards the feet with respect to the transverse plane
Right	Towards the right side of the body with respect to the sagittal plane
Left	Towards the left side of the body with respect to the transverse plane
Anterior	Towards the top half of the body with respect to the coronal plane
Posterior	Towards the bottom half of the body with respect to the coronal plane

Project Scope

- **Phase I (Fall Semester)**
  - Development of a rough/working model of the liver vasculature with specific surrounding vasculature
  - Development of a proper enclosure for this model with dimensions and materials appropriate for MRI compatibility
  - Single speed flow through use of current programmable flow pump provided by the lab
  - Safety and reliability testing to ensure device is ready for use in scan room
  - Usability testing with interventional radiologists to receive feedback on potential improvements and efficacy of design
- **Phase II (Spring Semester)**
  - Improvements on vasculature network detail
    - Possible 3D modeling and mold formation
  - Integration of pulsatile flow through provided programmable flow pump
    - Possibility of upgrading to a pump with greater capabilities upon proof of concept

- Development of a gel/liquid that mimics the T1/T2 relaxation times of liver tissue for MR imaging purposed
- Usability testing for additional feedback on design and suggestions for future revisions

Product Requirements:

- Phantom will require a port for catheter entrance located in the femoral artery (the site of the majority of catheterization procedures)
- Phantom will require 2-3 inches of space between the vasculature model and sides of phantom enclosure to minimize MRI artifact
  - This is especially true on the superior end of the phantom
- Size of enclosure: 24”x18”x8”
- Vasculature:
  - The phantom should include the following vessels:
    - Abdominal aorta
    - Left gastric artery
    - Left/Right Hepatic Arteries – leading to liver vasculature detailed below
    - Splenic artery
    - Left/Right renal arteries
    - Superior Mesenteric Artery (SMA)
    - Both Femoral Arteries
  - Liver vasculature should be detailed to the level of the eight arteries entering each of the eight Couinaud segments of the liver
  - Only arterial vessels need to be included as treatments are not generally delivered through venous vasculature
  - Liver vessel diameters:
    - Hepatic artery: 4-7mm
    - Left/Right hepatic artery: 2-5mm
    - Segmental arteries (Couinaud segments 2-8): 1mm
- The bottom side of the phantom should conform to the shape of the MR coil that it will be sitting in to minimize any potential damage to the coil from a heavy phantom.
  - This can be implemented through the use of a layer of foam separating the phantom and the MR coil
- The final weight of the product should such that it is capable of being moved by a single researcher (less than 80 pounds)
- Entrance/exit points to the phantom
  - Entrance
    - Aorta
  - Exit
    - 8 Couinaud segments
    - R/L femoral artery
    - Superior mesenteric artery
    - R/L renal artery
    - Left gastric artery
    - Splenic artery

Design Materials

- Design materials are currently undecided, and will be added to this list throughout the course of the project

    - All design material must be compatible with MRI
- The surrounding box will be made using acrylic sheeting
- Tube fittings outside of the box should be easily/quickly disconnected and reconnected for movement of phantom
- Tygon tubing will be used for the vasculature phase 1 prototype of the phantom
- Silicone based epoxy will be used to join the Tygon tubing
- Flow pump – a pump currently in use in the lab will be used for phase 1
    - Pump Details:
        - Masterflex L/S Analog Control peristaltic pump drive, model **HV-77521-40**
        - L/S High Performance Pump head, model **HV-77250-62**
        - Website reference: http://www.masterflex.com/catalog/product_view.asp?sku=7752140

Budget

- This project is funded by a grant that our client has obtained for the project