Transarterial Chemoembolization Simulation

Team Members – Justin Schmidt, Benjamin Engel, Ryan Carroll, Eric Printz
Client – Dr. Wally Block PhD – Departments of Biomedical Engineering and Medical Physics
Advisor – Dr. William Murphy PhD – Department of Biomedical Engineering

Abstract

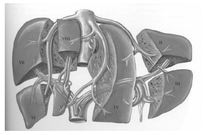
Liver cancer in various forms is a major cause of mortality worldwide and current treatment methods are highly ineffective. Transarterial chemoembolization (TACE) is a chemotherapy delivery technique which improves the localization of treatment. Currently, TACE is guided through X-ray imaging but would benefit from the use of real-time 3D MRI guidance. The purpose of this project was to create a set of testing tools to allow for the development and testing of MRI guided transarterial chemoembolization. In phase I a liver phantom was created which allows physicians to practice liver catheterization under MRI guidance. Phase II requires similar testing through the use of porcine test subjects. In phase II of this project a test subject transport device was created which allows the test subject to be transported from the MRI scanner to an X-Ray machine for catheter placement verification. The transport device was successfully tested to verify that catheter movement was under the specified 1cm tolerance. The device was also tested under extreme loads to verify that the device is capable of supporting twice the maximum weight of a pig test subject.

Problem Statement

It is proposed to design a set of testing components to aid in the advancement of MRI guided transarterial chemoembolization. **Phase I** involved the development of an MRI compatible liver phantom for catheterization practice under MRI guidance. **Phase II** involves the development of an animal subject transport table for simple transitions between MRI and X-ray imaging machines.

Background Information

- Current cancer treatment methods
  - Systemic chemotherapy: 20% response rate
  - 20% of tumors are inoperable
  - More localized / effective method is needed
- Transarterial chemoembolization (TACE)
  - Delivers high concentration of chemotherapy
  - Embolisms prevent chemotherapy diffusion
  - Currently X-Rays are used to guide catheter
  - Catheter administered to specific Couinaud segment
- Liver Phantom
  - Developed last semester
  - Used to allow physicians to practice MRI catheter guidance
  - Successfully tested and imaged
- Animal Subject Testing Protocol
  - Guide catheter into swine test subject using MRI guidance
  - Transport test subject from MRI to X-Ray
  - Verify catheter placement using traditional X-ray image



Block, WF. 3D Real Time MRI Imaging Grant. PHS 398/2590

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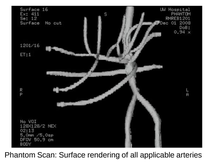
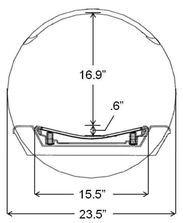


Phantom Scan: Surface rendering of all applicable arteries

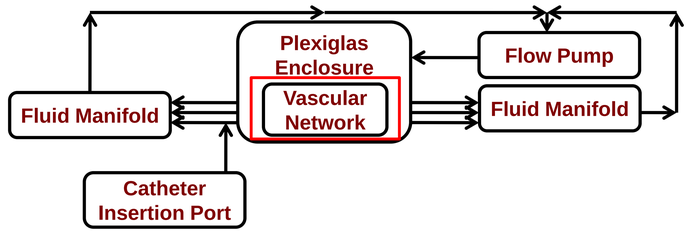
Client Requirements

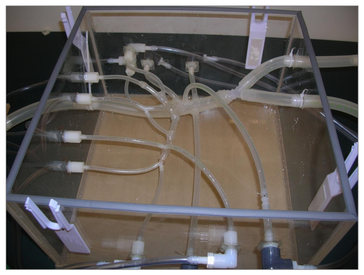
- MRI compatible
- Material: attenuation < PVC coil
- Compatible with MRI/X-ray tables
- MRI coil must be held securely during imaging and transport
- Maneuverable by two people
- Must support weight of the coil plus 60 kg (132 lb) specimen
- Catheter movement tolerance of 1cm
- MRI Spatial Constraints



Final Design/Components

Phase I: Liver Phantom





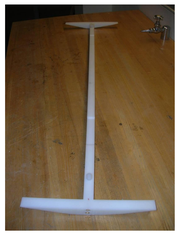
- Plexiglas® Enclosure
- Vascular Network
  - Tygon® tubing
  - Hot melt/silicone junctions
  - 8 Couinaud Segments
  - Key abdominal arteries
- Two fluid manifolds
- Catheter insertion port
  - Allows contrast injection
- Masterflex® analog control pump

Phase II: Subject Transport Table

Coil Support Straps

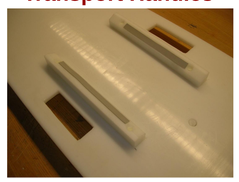
- Prevent coils movement during transfer
- Nylon fabric strap
- Quick release latch
- MRI compatible

MRI Couch Adapter



- Adapts device to curvature of MRI couch
- Pegs limit table movement

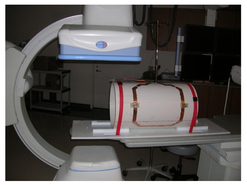
Coil Rail Supports and Transport Handles



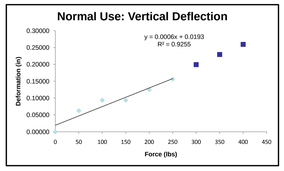
- Rails hold coil in place
- Rubber backing prevents coil rotation and sliding
- Handles increase ease of maneuverability

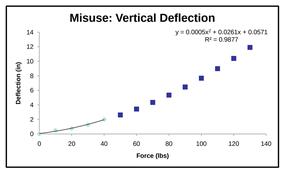
Device Compatibility

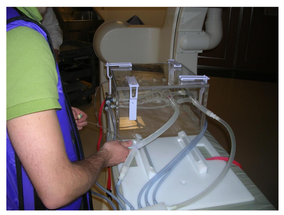
- Device adheres to spatial constraints of MRI bore
- Recessed bolts allow device to sit flush on X-ray table



Testing







Vertical Deflection Tests

- Placed supports under the handles for normal use testing and under the ends of the table for misuse
- Placed weights in middle of table from 0 pounds to 250 pounds in increments of 50 pounds
- Placed string across the width of the table for normal use and the length of the table for misuse and the deflection was measured between the table and the string
- Data was extrapolated using a linear regression for the normal use (R=0.9255) and a second degree polynomial for the misuse (R=0.9877). The theoretic points are shown in blue
- Reached deformation tolerance (.25 in) at 384.5lbs during proper use
  - Safely accommodates maximum pig weight (safety factor = 2.91)
- Safety factor during misuse = 0.05

Catheter Movement Tests

- Three different MRI to X-ray phantom transfers were performed
  - Phantom transfer without the use of transfer table
  - Phantom transfer with the use of transfer table
  - Phantom transfer with the use of transfer table and catheter secured to the port
- Transfers in all three cases resulted in zero linear catheter movement safely within the 1 cm tolerance

Future Work

- Perform MRI guided catheterization training for physicians using phantom
- Adapt phantom for use in other imaging studies
- Obtain IRB approval to begin porcine subject testing
- Perform physician training using porcine subject

- **Ultimate goal: Use tools to prove efficacy of MRI guided catheterization for a variety of procedures using TACE as an initial test platform**

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