**Background**

- The liver is the most common site for metastases of gastrointestinal and malignant melanoma cancer tumors.
- VX-2 carcinoma tumor model is the most common model for studying liver cancer growth and developing potential treatments for humans.

**Existing Methods**

Open Laparotomy:
- Most common method
- Easy access to site of implantation
- Accurate placement of cells
- Minimal unwanted cell seeding in abdominal cavity
- Long procedure and recovery time
- Anesthetic complications

Percutaneous:
- Less invasive
- Shorter procedure and recovery time
- Less anesthesia
- Decrease technical skill required to perform
- Sonographic imaging for guidance
- Increased unwanted seeding of tumor cells
- Difficulty closing internal injection site

**Problem Statement**

Certain models of cancer require surgical implantation of tissue fragments. Percutaneous injection is the preferred method for implantation over open surgery because it is less invasive. Percutaneous methods have limitations including difficulty closing the hepatic incision, tumor seeding in unwanted areas, and backflow of tumors during the procedure. Our goal is to design an improved tissue fragment injection system that effectively eliminates these complications using biocompatible materials and biopsy needles, while also lowering the technical skill required to perform the procedure.

**Materials**

Poly(lactic-co-glycolic acid) (PLGA):
- Broken down via hydrolysis mechanisms in the body
- Customizable degradation time
- FDA approved
- Biocompatible
- Mechanical flexibility

Poly N-isopropylacrylamide (pN-IPAAm):
- Thermoresponsive polymer
- FDA approved
- Gels as lower critical solution temperature (32–37°C)

**Key Design Specifications**

- 5mm x 3mm rectangular sheet of PLGA made by electrospinning
- Tissue fragments folded inside of PLGA sheets
- Prevents unwanted seeding along injection pathway
- 17-gauge coaxial needle for injection
- Needle loaded with blunt stylet that fits inside

**Protocol:**

- Cut 8mm tissue fragment and 5mm x 3mm PLGA sheet
- Wrap tissue in PLGA sheet
- Backload fragment into needle
- Using blunt tip stylet, push tissue fragment 2cm from tip of sheath
- Stick stylet 5cm into liver
- Push stylet through remainder of sheath to eject fragment
- Retract stylet from tip of sheath
- Remove both needles

**Table 2:** Various concentrations of PLGA in THF-DMF solvent with a voltage of 18kV and a 16cm working distance. Two different molecular weights tested.

<table>
<thead>
<tr>
<th>PLGA MW</th>
<th>Weight Percent</th>
<th>Voltage</th>
<th>Working Distance</th>
<th>Fiber alignment</th>
</tr>
</thead>
<tbody>
<tr>
<td>700k 17k</td>
<td>30% 18kV 16cm</td>
<td>poor fiber direction</td>
<td></td>
<td></td>
</tr>
<tr>
<td>700k 17k</td>
<td>30% 18kV 16cm</td>
<td>improved fiber direction</td>
<td></td>
<td></td>
</tr>
<tr>
<td>700k 17k</td>
<td>30% 18kV 16cm</td>
<td>optimal fiber direction</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Testing**

Electrospinning Optimization

**Figure 3:** Electrospinning set-up. Using a 16-gauge needle, 18kV, and a working distance of 16cm, PLGA fibers were spun on to aluminum foil.

**Figure 4:** Images of fibers from electrospinning at 20X, 25 weight percent PLGA (Mw 7,000 kDa), 30 weight percent PLGA (Mw 100,000 kDa). Plaques injected after to fill injection site hole.

**Table 3:** Various concentrations of PLGA in THF-DMF solvent with a voltage of 18kV and a 16cm working distance. Two different molecular weights tested.

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</table>

**Infection Method**

**Table 4:** Various concentrations of PLGA in THF-DMF solvent with a voltage of 18kV and a 16cm working distance. Two different molecular weights tested.

<table>
<thead>
<tr>
<th>Item</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control Needle</td>
<td>$99.99</td>
</tr>
<tr>
<td>1 gram PLGA (50:50, Mw 100,000)</td>
<td>$17.83</td>
</tr>
<tr>
<td>1 gram N,N-Dimethylformamide (DMF)</td>
<td>$4.33</td>
</tr>
<tr>
<td>TOTAL COST</td>
<td>$233.40</td>
</tr>
</tbody>
</table>

**Future Work**

- Determine and customize degradation time of PLGA
- Simulate injection of rabbit liver environment
- Improve efficiency of encapsulation process
- Lower technical skill required
- Decrease time required
- Eliminates optimal conditions to study sheets of PLGA
- Optimize temperature
- Optimize storage time
- Optimize cost
- Optimize in method and device is achieved, test on recipient rabbits.

**References**


**Acknowledgements**

Dr. Randolph Ashton • Dr. Chris Brace • Zhiyuan Gu • Lisa Sampson • Maria Ruiz