Promoting and Assessing Cell Capture in a Wicking Fiber Cancer Predictive Tool

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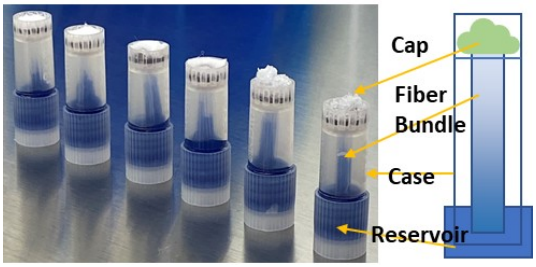
Purpose: We have been developing a fiber-based, predictive, point of care device to allow a clinician to quickly assess the state of a cancer and most appropriate therapy. The technology comprises unique "wicking" fibers that can move and distribute a heterogeneous collection of cellular liquids across their lengths. A bundle of wicking fibers, capped with an absorbent material provides a very simple conduit and sink to quickly assess cell mobility and cell type. An evaluation of cellular matter in the cap provides an insight of the current disease state. This technology can be rapidly implemented in veterinary applications, where resources and funding are often limited.

Previous studies [1,2] have confirmed that polylactide fibers with non-circular cross-sections are efficient at wicking cells along their channels and allowing malignant cells to separate from benign cells based on their morphologic differences. Due to the increased deformability and lack of cell adhesion molecules on the surface of malignant cells, they are able to wick more quickly to the top of the fiber bundle and be captured in a cap. This device has the potential to act as a bench-top diagnostic tool for clinicians to quickly interpret a cell sample for the presence of cancer. Recent experiments were run to determine the material needed to successfully capture and view cells in a removable cap in order to perform an accurate cell count and analysis.

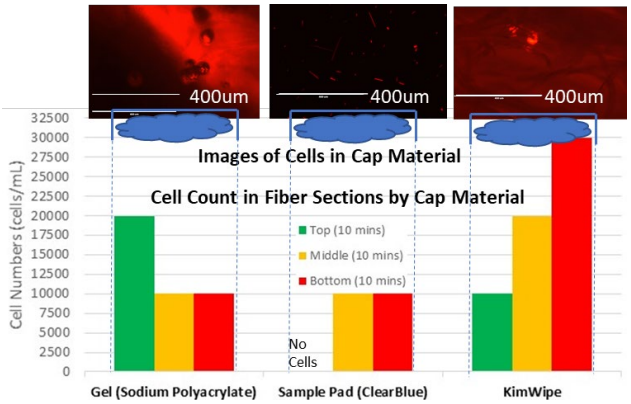
Methods: The surfaces of eighteen polylactide fibers (PLL) with 30mm length each were treated with 70% ethanol and 10% Lysol for 15 minutes each and allowed 24 hours to dry. Bundles were made with three fibers and held together using a prototype made from a modified freezer vial. Six bundles were prepared with three different absorbent materials in the caps: sodium polyacrylate gel, ClearBlue pregnancy test sample pad, and a Kimwipe.



Fibroblasts (3T3M) were fluorescently stained with RedTracker and GreenTracker dyes and resuspended in phosphate buffered saline (PBS) at a concentration of $2.2x10^6$ cells/mL. One mL of solution was placed in the wells of each fiber bundle and allowed to wick. Three bundles, each containing different cap materials, were pulled out of the wells at 5 minutes, and the other three bundles were removed at 10 minutes to compare wicking rates. The caps and wells of each bundle were removed and the bundles were immediately placed into a -80°C freezer for 24 hours, then the fibers were analyzed.

After 24 hours, the bundles were positioned horizontally on an acrylic stand and cut into three sections using a laser cutter. Three sections (top, middle, and bottom) of each of the six bundles were then individually centrifuged at 1200 rpm for 5 minutes in 0.2 mL of PBS and cell counts were performed on each bundle.

Results and Discussion:



The cap material was assessed as to: 1) ease of viewing the captured cells with a fluorescence microscope, and 2) absorbency. An issue common to all three absorbent materials was an inability to accurately view or count the cells due to the thickness, lack of uniformity and transparency, as well as the amount of debris from the cap material. The paper-based caps (ClearBlue sample pad and Kimwipe) had the least cell visibility due to the material blocking the passage of light through the microscope. The sodium polyacrylate gel-based cap had the best cell visibility and the most consistent cell numbers, however, a cell count still could not be performed due to the thickness of the jelly-like material allowing dozens of cells to stack on top of each other.

To estimate the number of cells captured in each cap, cells that remained in the well and on the bundle were counted and subtracted from the original concentration. The sodium polyacrylate gel-based cap had the highest cell count among all three.

Conclusions: The cap concept is promising but needs to 1) promote wicking and 2) provide easy analysis. A realistic wicking time for these bundles, allowing sufficient cell capture, is 10 minutes.

Future Work: Future work will involve designing a transparent cap with very thin, uniform consistency and focusing on developing a mechanistic understanding of wicking.

References:

[1] Tabbaa SM, Sharp JL, Burg KJL. Ann Biomed Eng. 45:2933-41;2017.
[2] Tabbaa SM, Burg KJ. Trans Ann Meeting Soc Biomater. 2014.

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