EMPLOYING BUOYANCY TO EXTRACT MICROEMBOLUS-SIZE MICROBUBBLES FROM FLOWING FLUID: QUANTIFICATION WITH A UNIQUE MATLAB ALGORITHM

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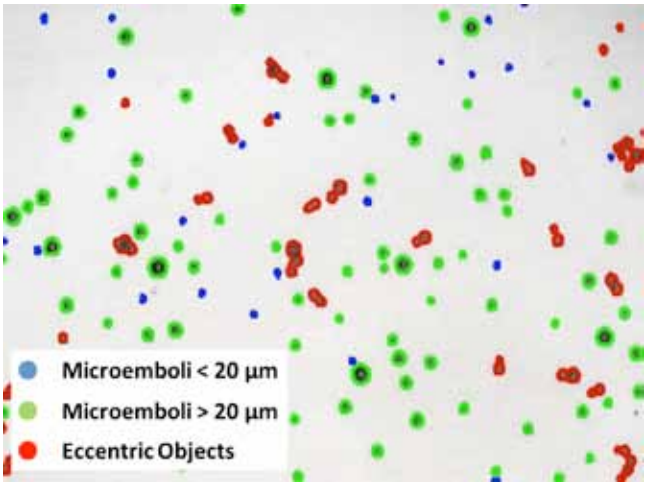
Summary: A Matlab script to characterize microembolus-size bubbles in flowing fluid was created to assess efficacy of a prototype device designed to model removal of microbubbles from extra-corporeal blood flow for heart-lung bypass. Microembolus size and shape characteristics are superimposed on video images for visual assessment.

Hypothesis: Microbubbles of sizes thought to contribute to cognitive deficits after cardiopulmonary bypass can be quantitated and attrition demonstrated in rapidly flowing fluids.

Introduction: Cardiopulmonary bypass machines are known to introduce microemboli into circulatory tubing and thus into the patient. Current generation arterial filters serve as a barrier to microemboli, preventing the circulation of microemboli larger than about 40 microns in diameter. However, microemboli of less than 40 microns have been shown to be detrimental to patient health. Pore or lattice barrier filters with smaller passages have excessive resistance to flow and produce excessive shearing damage to blood cells. Therefore, a device employing a different mechanism capable of preventing circulation of microemboli less than 40 microns could be beneficial. Microemboli less than 20 microns in diameter are thought to be inconsequential to human health and thus do not need to be removed during extra-corporeal circulation. Proof that a device is capable of preventing the circulation of hazardous microbubble emboli requires verification that microemboli are reduced. This study presents an innovative method for the quantification of microemboli in flowing fluid. This novel quantification method was employed to assess design changes to a novel microemboli extraction device.

Methods: Experimental Setup: A flow loop was constructed in which water was pumped at 400 mL/min through 3/8 inch rigid square acrylic tubing. Stable 10-40 micron microemboli were created in an albumin solution by hand agitation. These microemboli were then introduced into the flow loop. Optical microscopes with video recording capability were set at 40x magnification. Video of the albumin-stabilized microemboli within the flow channel were recorded at positions before and after the extraction device.

Microemboli Quantification: Recorded videos were post-processed with a novel Matlab script. The script accurately records the number and size of microemboli within video frames. Additionally the script recreates the processed video and color codes objects detected (Image), allowing for the rapid verification of the detection algorithm. Diameter, area, and eccentricity of the labeled microemboli are saved for future processing.



Bubble size (microns)	P-value for one-tailed t test
20-25	0.2475
25-30	0.0811
30-35	0.0059
35-40	0.0004

Results: Preliminary confirmation of the efficacy of this novel extraction device was obtained using this detection technique for a variety of experimental conditions. Extraction was statistically significant for microemboli larger than 30 microns, but not significant for extraction of microemboli smaller than 25 microns (Table). Extensive additional development and testing are needed.