Whole-Body MRI to Assess Perfusion Success and Soft Tissue Injuries in PMHS Subjected to High-Rate Loading

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Introduction: Post-mortem human subjects (PMHS) are the closest surrogate for research pertaining to the human body across many disciplines. In injury biomechanics, PMHS have been critical in studying biomechanical response to blunt impacts. In high-rate blunt impacts, similar to those that produce behind armor blunt trauma (BABT), contusions (i.e. bruising) of tissues including the lung and the liver are commonly noted. A major limitation of using PMHS as biomechanical surrogates is the lack of pressurization in the lungs and vasculature that are present in living humans. Therefore, there is an inability to create the contusions that can result from high-rate blunt impact loading. When microvascular damage occurs in a pressurized PMHS in response to a blunt impact, there is currently no methodology to assess or quantify the "bleeding" caused by the impact. The study aims to address this gap in the existing research.

Objective: The aim of this study is to develop a methodology to visualize extravasation that signifies vascular damage (and therefore soft tissue injury) in response to blunt impact with whole-body contrast enhanced magnetic resonance imaging (MRI).

Methodology: The vasculature of three (3) PMHS was perfused/pressurized with a colloidal perfusate solution consisting of saline, paint of a non-physiologic color (fluorescent green), and Gadavist®, a gadolinium-based contrast agent that enhances the signal captured by MRI images. The PMHS were then impacted with the goal of causing soft tissue damage, and therefore extravasation. The PMHS were subjected to whole-body MRI on a clinical 3T scanner (Siemens MAGNETOM Cima.X) prior to the introduction of the contrast agent and soft tissue damage (pre-impact), and after perfusion and soft tissue damage (post-impact). Autopsies were performed after the post-test MRIs. T1 and T2-weighted MRI images were compiled and reviewed by a radiology resident. The post-impact images were compared with the pre-impact images and the autopsy results.

Results: Contrast enhancement was noted in post-test MRIs in the thoracic aorta and segmental/subsegmental pulmonary arteries for two (2) of the three (3) PMHS. The specimen that did not show notable contrast enhancement was found to have whole-body pathology that could affect vascular health that was unknown at the time of the test. Hard tissue injuries such as rib fractures and soft tissue defects including lacerations and edema were noted in MRI imaging and were consistent with autopsy findings. Pooling of the contrast was also noted, as well as minimal contrast in the distal lungs. However, good enhancement in the liver and systemic vasculature was noted. No obvious contrast extravasation was noted in two tests, although severe soft tissue injuries were noted. Migration of the perfusate was also noted, as there was evidence of contrast in areas where the perfusate migrated due to gravity.

Conclusions: The results of the first three (3) PMHS indicate promise in the assessment of soft tissue injuries in PMHS with the contrast-enhanced 3T whole-body MRI. Further work is needed to improve the methodology to allow for enough perfusate to be introduced to each PMHS to ensure the best possible agreement between autopsy findings and MRI analysis.

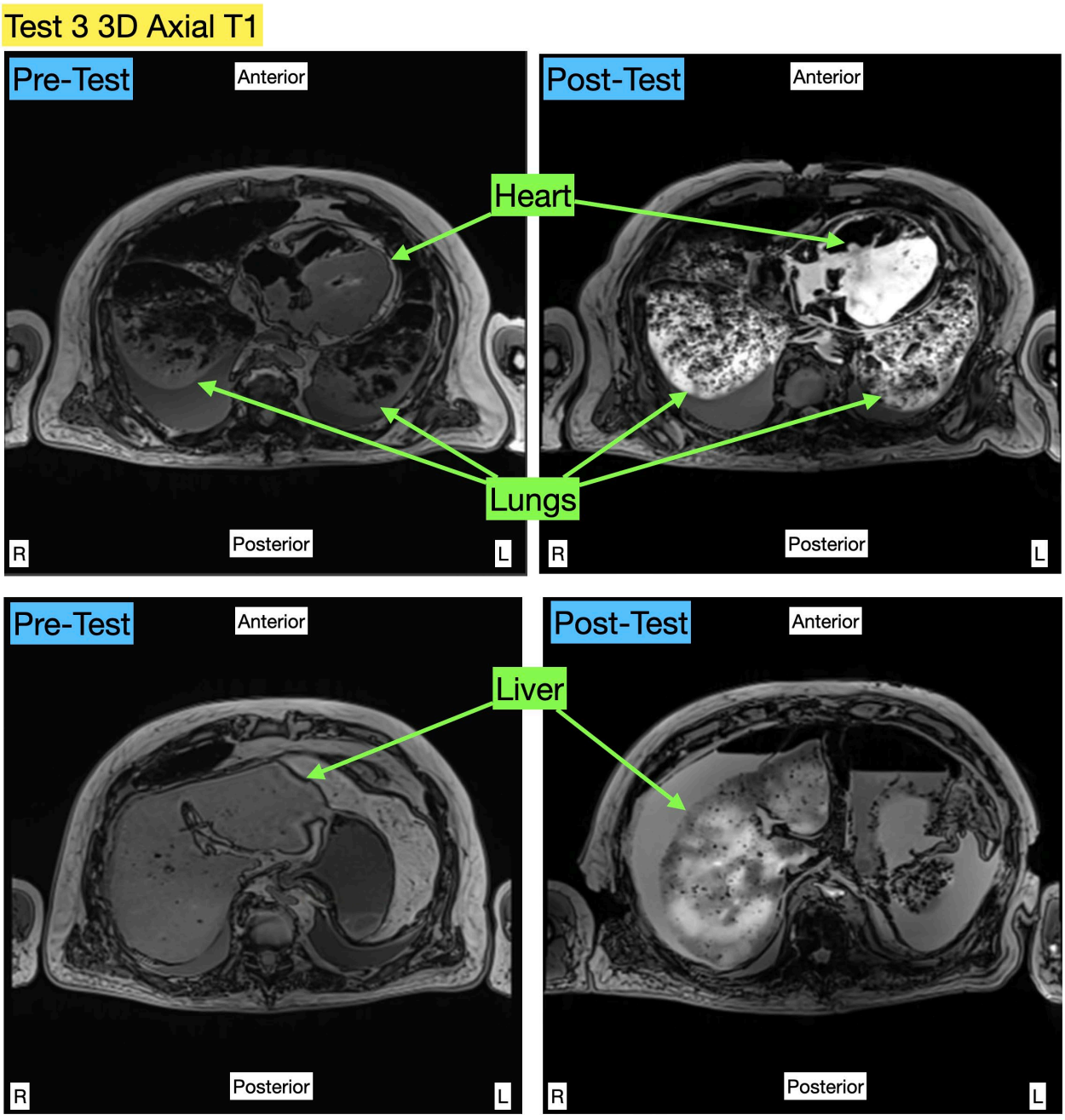

Figure 1: Pre-test (left) and post-test (right – contrast enhanced) whole body MRI depicting axial views of the heart, lungs, and liver.