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

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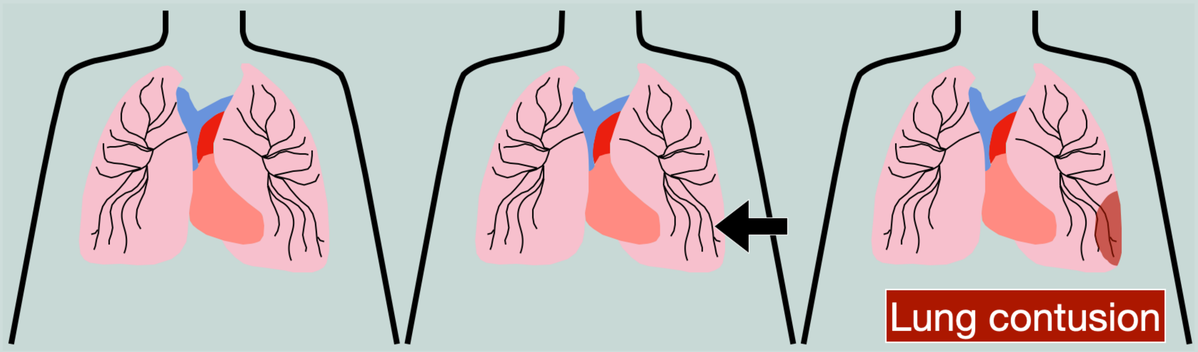
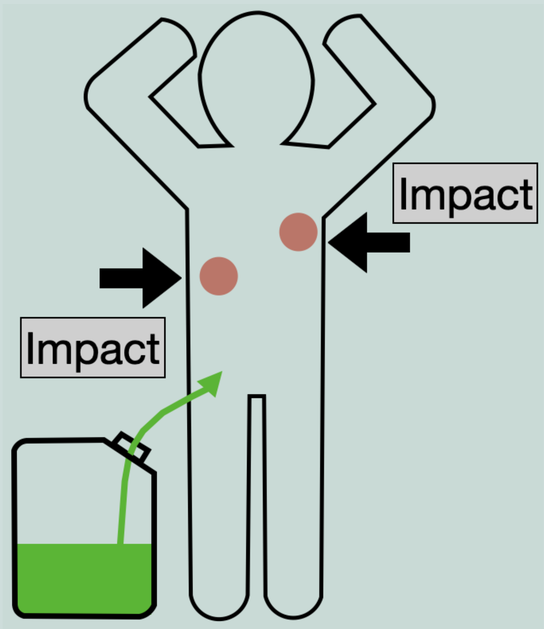
Study Overview

Post-mortem human subjects (PMHS) are a useful surrogate in injury biomechanics and 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. Currently, the lack of vascular pressurization in PMHS is a major limitation when aiming to study 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.



Methodology

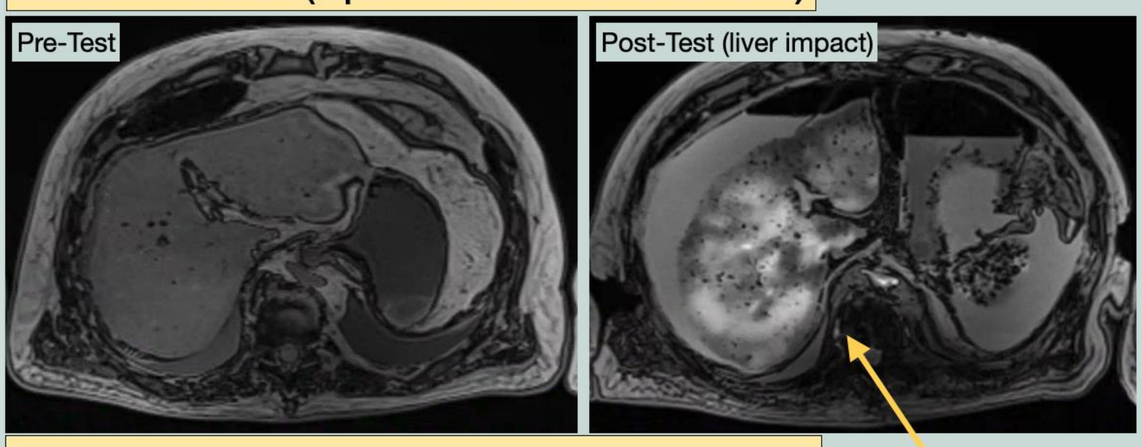
The vasculature of four (4) PMHS was perfused/pressurized with a solution consisting of saline, fluorescent green paint, and Gadavist®, an MRI contrast agent. The PMHS were then impacted with the goal of causing soft tissue damage, and therefore extravasation. The PMHS were subjected to whole-body MRI before and after the introduction of the contrast agent and soft tissue damage (pre- and post-impact). Autopsies were performed after the post-test MRIs and injuries were documented. The MRI images were compiled, reviewed, compared with the pre-impact images and the autopsy results.



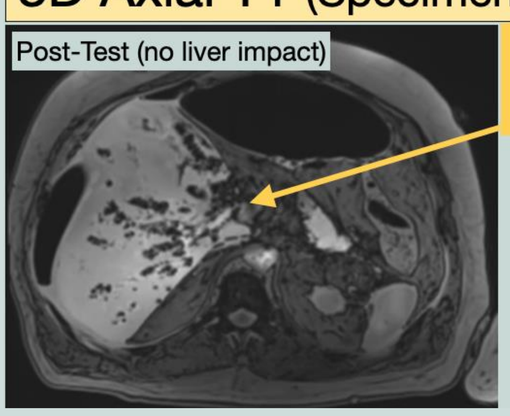
Results

Contrast enhancement was noted in post-test MRIs in the thoracic aorta and segmental/subsegmental pulmonary arteries for 3 of the 4 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. Heterogeneous enhancement and blooming artifact in the liver was also noted, which was indicative of diffuse liver injury. Pooling of the contrast was also noted in the posterior aspect of lungs when the specimen was stored in a supine fashion due to migration of contrast due to gravity, and minimal contrast was noted in the distal lungs. No obvious contrast extravasation was noted in two tests, however, heterogeneous enhancement due to diffuse liver injury was noted in all tests where the liver was injured (3 of 4 tests).

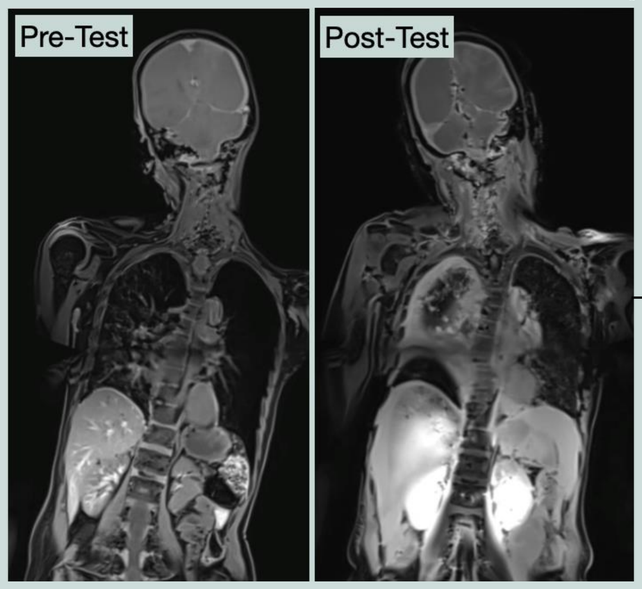
3D Axial T1 (Specimen ID: Frozen P3)



3D Axial T1 (Specimen ID: Frozen P2)



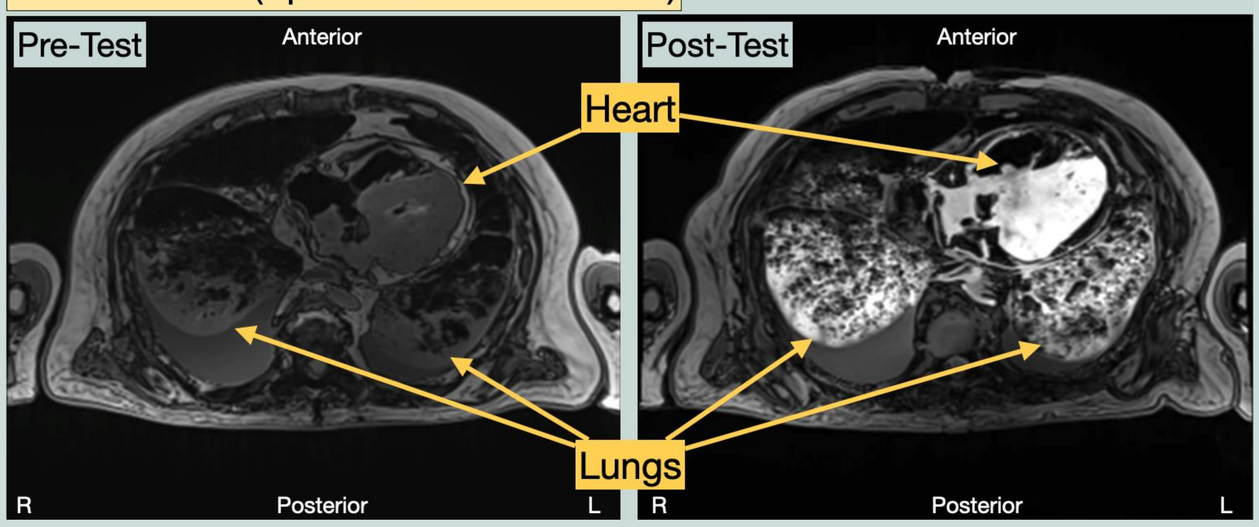
In tests with a liver impact, heterogeneous contrast enhancement was seen with blooming artifact, which is indicative of a diffuse liver injury. In a test with perfusion and no liver impact, heterogeneous enhancement was not present.



Contrast enhancement is seen in the post-impact liver scans. There is also a pleural effusion in the area of the right lung, which could affect where the contrast agent traveled within the lung tissue during testing.

The heterogeneous enhancement of the lung segments and liver is indicative of mixing of the contrast with blood and is also a possible indicator of trauma. Anterior lung segments were non-enhancing, likely due to contrast drainage during overnight storage.

3D Axial T1 (Specimen ID: Frozen P3)



Conclusions and Future Work

The results of the first four (4) 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.

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