Evaluating the Abdominal Response of a Porcine Surrogate to Lap Belt Loading

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To better understand the abdominal response of pediatric occupants undergoing belt loading, a porcine surrogate (*sus scrofa domestica)* has been developed to represent the abdomen of a 6-year-old human. A custom test fixture was designed to replicate two-point transverse belt loading across the anterior abdomen at rates up to 7 *m/s*. Five independent parameters were varied—abdominal compression, belt loading velocity, location of belt loading, loading waveform (ramp-hold *vs.* ramp-release), and the presence of abdominal muscle tensing—for a total of 21 unique conditions and 47 total dynamic tests. The upper abdomen tests directly loaded the lower ribs, liver, spleen, and stomach, while lower abdomen tests involved direct loading of the small and large intestines. Quasi-static compression tests were also performed to model the force-deflection response of the abdomen with and without active muscle tensing.

Injury risk functions were created to evaluate the robustness of various predictive criteria, and the Goodman-Kruskal gamma was calculated for each criterion to assess its predictive ability. Force- and compression-based criteria, such as maximum posterior reaction force, maximum belt force, and maximum abdominal deflection, proved to more predictive than velocity or viscous criteria such as $(V*C)_{max}$. The presence of muscle tensing was noticeable only in quasi-static tests, due to the lower reaction forces. The most common injuries associated with the upper abdomen tests were rib fractures, liver lacerations, splenic lacerations, and kidney contusions. The lower abdomen tests tended to produce mesenteric lacerations and contusions of the small intestine, and ruptures of the large intestine. These injuries occurred in frequencies comparable to those observed in actual real-world crashes. These findings will later be used to develop a reusable, biofidelic abdominal insert for the 6-year-old Hybrid III ATD.