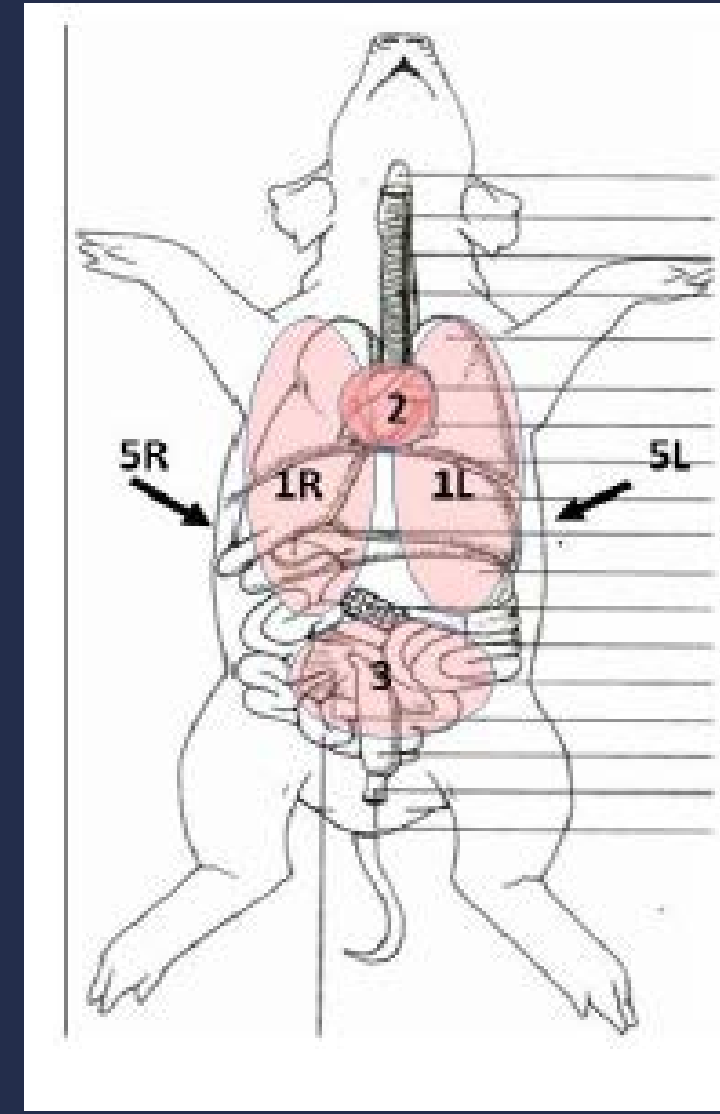




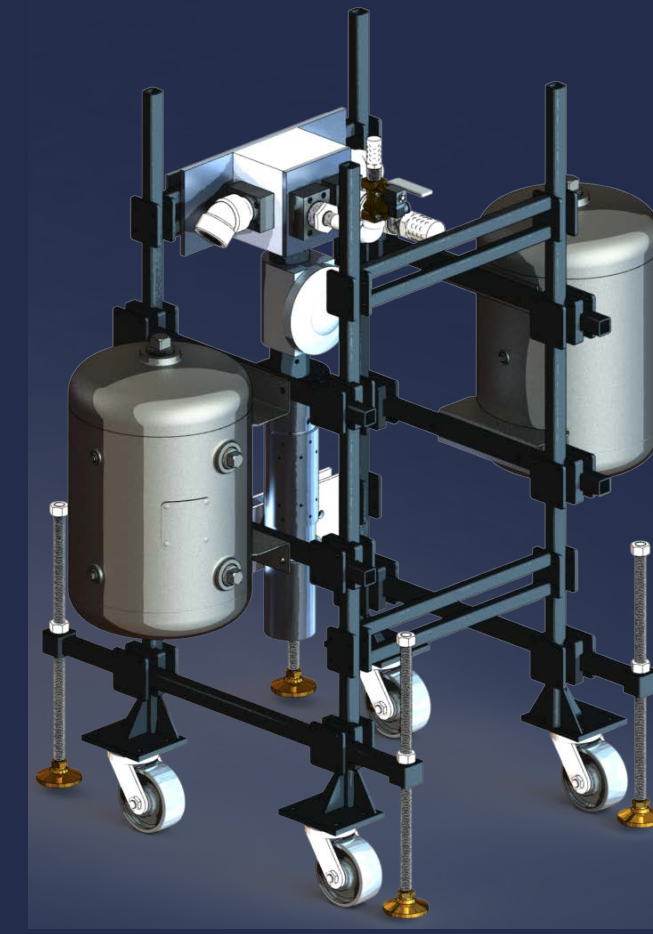
Introduction

- Behind Armor Blunt Trauma (BABT) occurs when body armor stops a projectile without penetration but deforms the armor a finite distance into the wearer's torso.
- The National Institute of Justice (NIJ) assesses body armor back-face deformation (BFD) performance by measuring by its deformation in Roma Plastilina™ modeling clay.
- The NIJ BFD standard is not currently correlated with any human model, human surrogate model, or human finite element model (FEM).



- To obtain physiological response/injury from BABT type insults, live porcine tests are being conducted with instrumented indenters that target different thoracic regions.
- This presentation focuses on blunt impacts to the upper left thorax (heart) of unprotected anesthetized porcine to:
 - Objective 1: Determine the range of impact energies resulting in visible cardiac contusions;**
 - Objective 2: Sample pre-test, immediately post-test, and 6-hour post-test Troponin I levels;**
 - Objective 3: Relate impact energies, Troponin I levels, and observed cardiac contusions in a live animal model.**

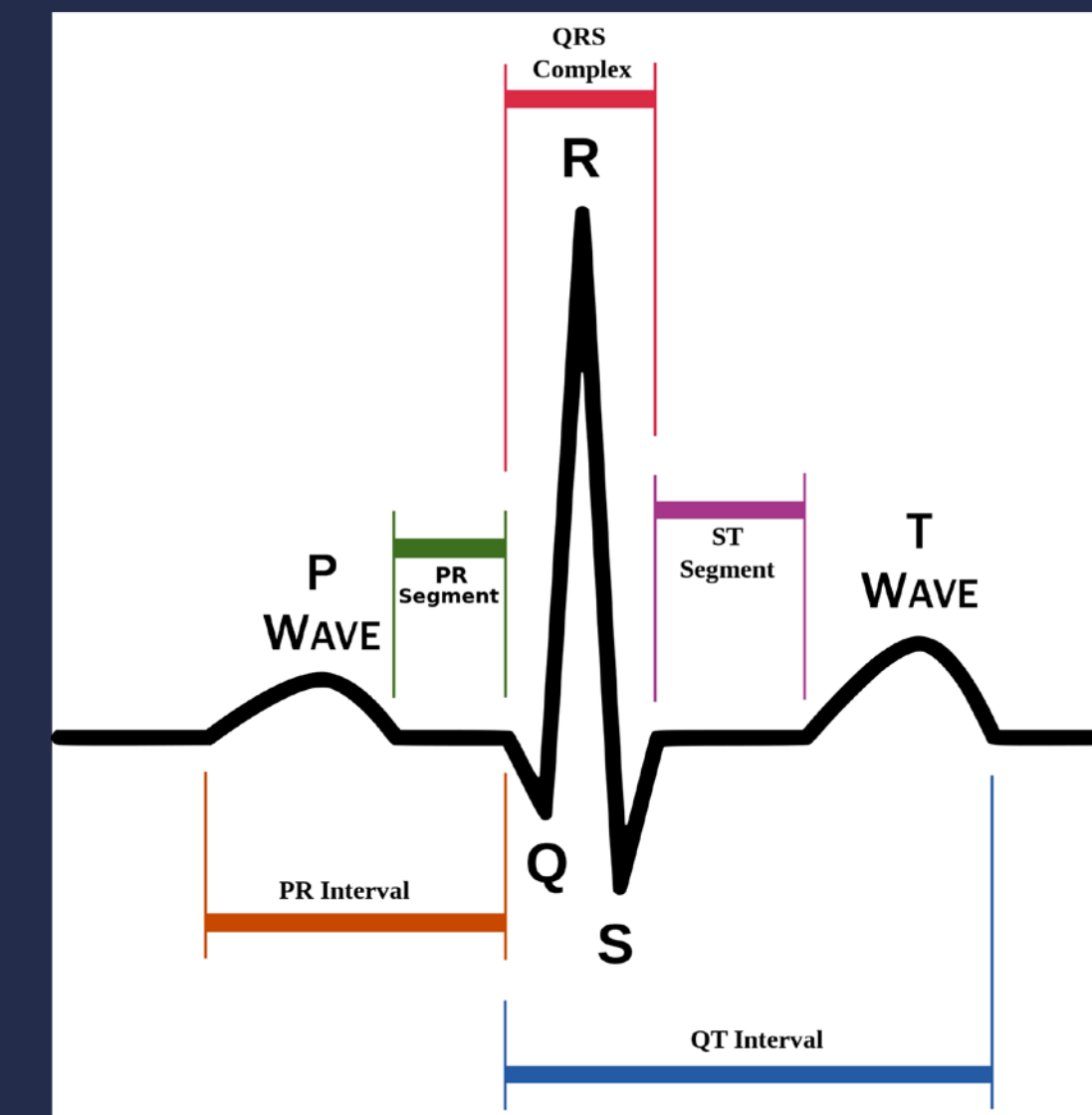
Methods



- Porcine Tested: 34
 - Mass: 42.9 ± 4.5 kg**
 - Length: 109 ± 5 cm**
 - Chest Wall Thickness: 2.31 ± 0.30 cm**
 - Heart Mass: 8.5 ± 2.1 oz**
- Instrumented Indenters
 - ID1 (parabolic): 27**
 - ID2 (cone): 7**

Ventricular Fibrillation Risk

- Risk of V-fib is equivalent to the duration of the 'rising' T wave divided by the duration of the cardiac cycle
- Risk of V-fib is known; therefore, we must investigate alternative injury outcomes for cardiac impacts



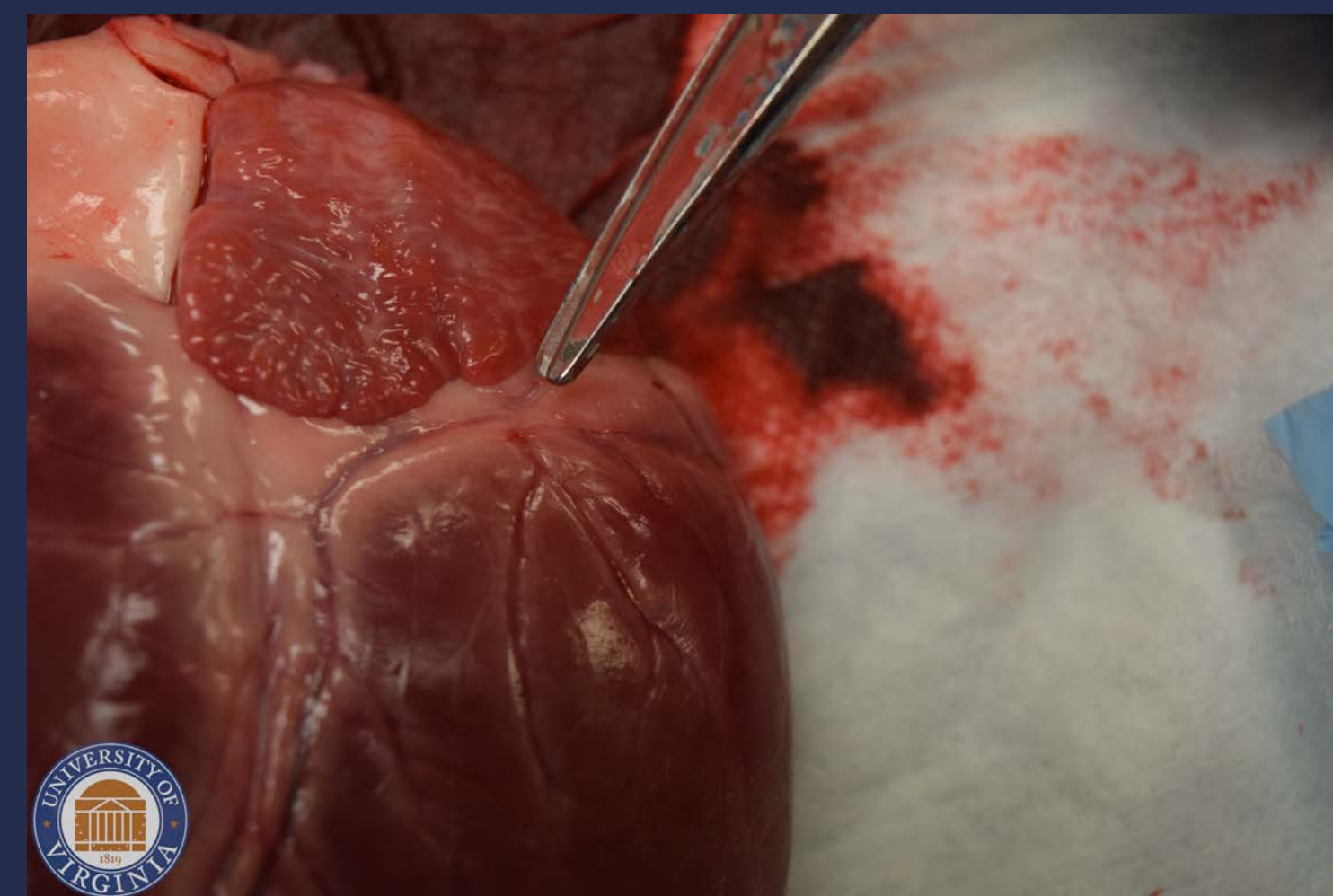
Custom Computer-Aided Triggering System

- BABT Impact System
 - Capable of delivering impact velocities of 10 – 50+ m/s**
 - Capable of impacting at specific intervals of the cardiac cycle**
 - Avoid the rising T-wave due to porcine susceptibility to ventricular fibrillation during this interval**



Results

Case Study 1 (LP100) Recoverable Arrhythmia

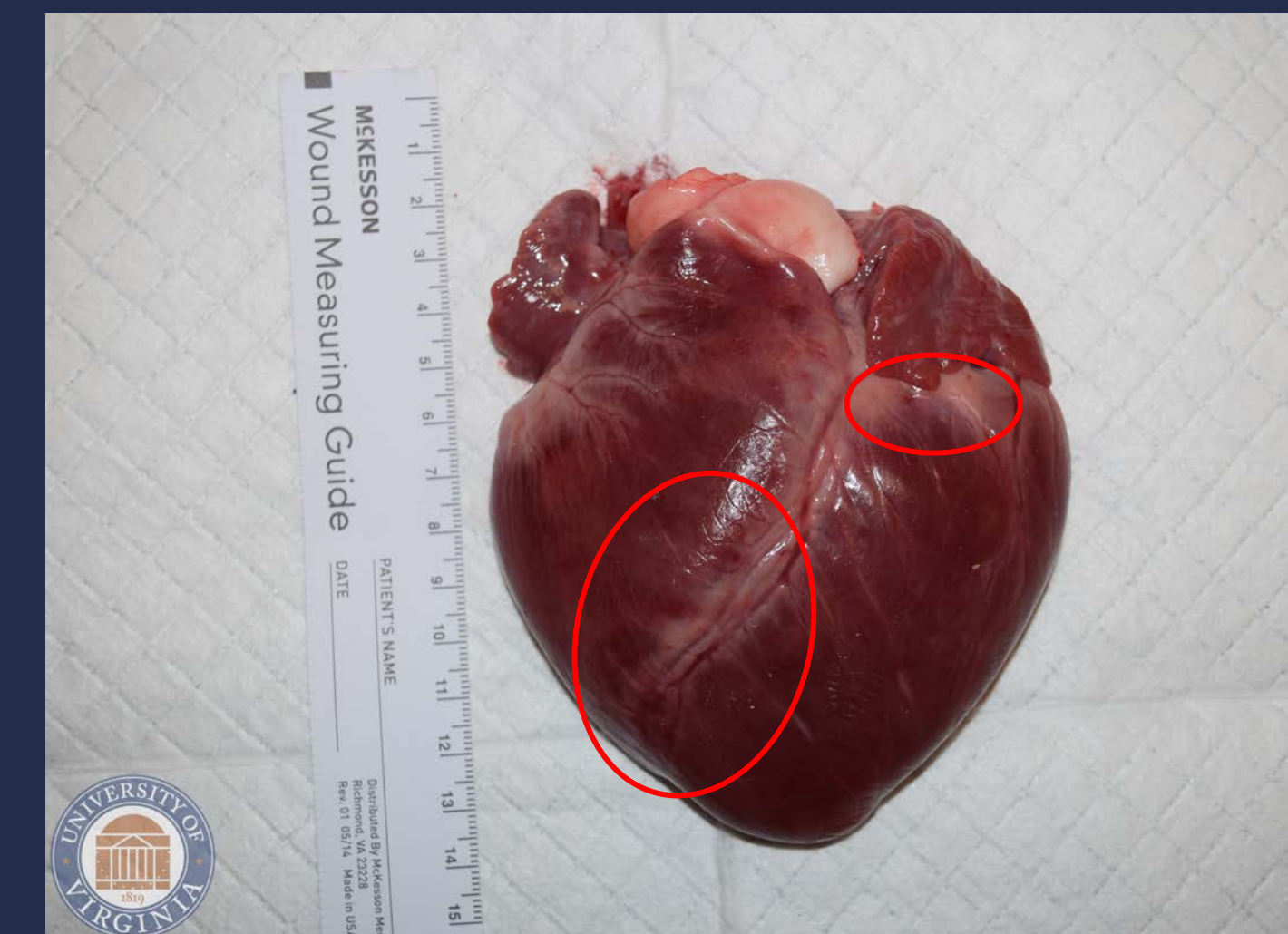


Velocity (m/s)	21.6
Energy (J)	60
Intrusion (mm)	55.7
Troponin I (ng/L)	1500

- Immediately post-impact
 - No loss of breathing**
- Damage
 - Single contusion in left ventricle**



Case Study 2 (LP122) Recoverable Arrhythmia

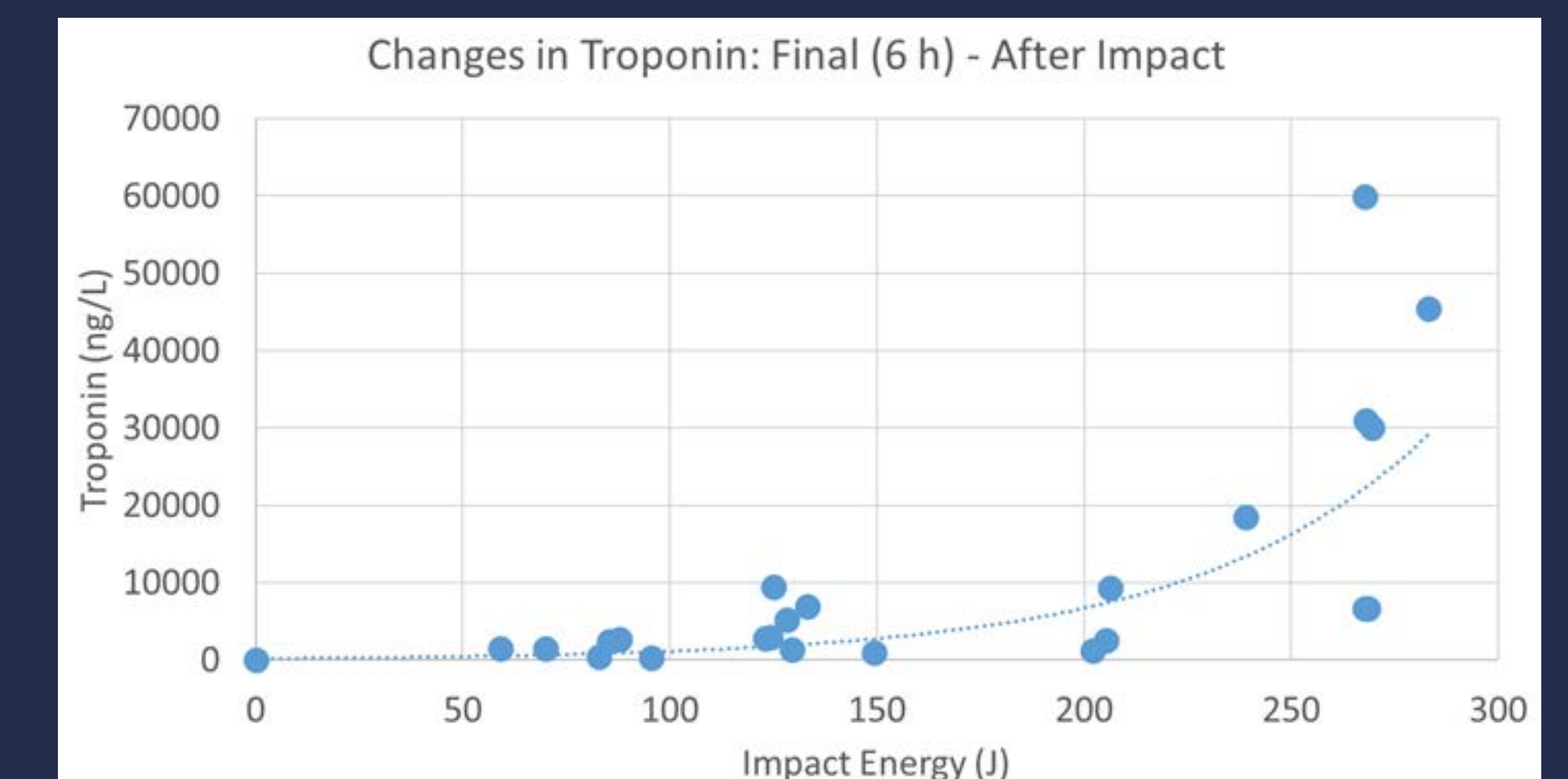


Velocity (m/s)	46.1
Energy (J)	270
Intrusion (mm)	67.5
Troponin I (ng/L)	60,000

- Immediately post-impact
 - 1 min 49 sec loss of breathing**
- Damage
 - Contusions along right and left ventricles**



Discussion



- 270J caused 60000 ng/L Troponin I were associated with blood in pericardial fluid, aneurysm and laceration of aorta, contusions in bilateral ventricles.**
- 60J caused 1500 ng/L Troponin I were associated with an increase in pericardial fluid and a single contusion in left ventricle.**

Conclusions

Levels of Troponin I are demonstrating to be a good indicator of the extent of cardiac contusion and functional capacity from ballistic behind armor blunt loading post-6 hours, without requiring exploratory surgery, allowing battlefield physicians to accurately diagnose and triage the injury.

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