

Patient Injury Potential from Mechanical CPR Devices During Collision: Comparison of Load-Distributing Band Versus Piston-Driven Systems

TECHNICAL REPORT

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Use of mechanical devices to perform chest compressions during CPR is growing, in part, because they make it safer for crews to treat cardiac arrest patients in a moving vehicle. Medics are protected from the forces that create imbalance during normal travel and collisions since they remain safely belted in their seats while the device performs chest compressions. However, patient safety has been an issue.

In the past, piston-driven technologies have been problematic since their top-heavy design made their movement unpredictable during rapid deceleration. The volatile nature of this movement has an added potential to injure patients otherwise safely secured in the vehicle. The recent introduction of a new load-distributing band technology promises to lower the risk of patient injury.

Purpose: This test compared the potential for patient injury of different mechanical CPR technologies by examining their behavior during rapid deceleration.

Method: Two different mechanical CPR systems were evaluated during simulated, rapid deceleration. Both piston-driven (Lucas™ 2) and load-distributing band (AutoPulse®) systems were tested. The test was conducted on a spring-driven crash sled to which an ambulance stretcher (including mattress and rails) was mounted (Figure 1). The test fixture complies with the requirements of DIN EN 1789 in that it could produce a calibrated g-force in 5 directions for a period of no less than 50 milliseconds.

The CPR systems were applied to a full body mannequin (Muckle Mannequins Polyman) in accordance with the manufacturer's recommendations.^{1,2} The mannequin was strapped onto the stretcher using a standard five-point harness (Ferno, Inc.).



Figure 1: Test sled with stretcher and shoulder harness.



Figure 2: The top-heavy mass of the piston-driven system forcefully impacts the mannequin's head at 250 milliseconds.



Figure 3: Lower part of the piston-driven system severely deforms the back of the mannequin at 250 milliseconds.

Both systems were exposed to a simulated 10-g deceleration for a duration of 55 milliseconds while actively performing compressions on the mannequin. A calibrated sensor (Wilcoxon Research Model 786A) and signal amplifier (Althen VIB-KS-24-010-pk) were used to measure the resulting g-forces and time duration. They were attached to a calibrated oscilloscope (Tektronix TDS1012B) for precise measurements. The trials were captured on a high-speed camera system (Casio EX-F1).

Findings: During deceleration, three observations are reported on the piston-driven system:

- 1 It tilted to the point where the mass of the system (control unit, battery, and motor) forcefully impacted the mannequin's head (Figure 2).
- 2 The back of the mannequin was excessively deformed (Figure 3) in a manner suggesting some level of spinal injury.
- 3 The piston failed to stop despite it having moved to a non-therapeutic position (i.e. abdomen, lateral rib cage, etc.).

With the load-distributing band system, movement was limited adequately by the shoulder harness such that no abnormal forces were delivered to the mannequin (Image 4).



Figure 4: Minimal movement of the mannequin at 250 milliseconds with the load-distributing band system in use.

Conclusion: This front-end crash simulation suggests the load-distributing band system (AutoPulse) behaves in accordance with DIN EN 1789 and is not likely to evoke injuries to the patient. In contrast, observations suggest that the piston-driven system (Lucas 2) has the potential to cause serious injuries to the head and the spine. Further, there is the added potential for the dislocated piston to injure other parts of the body or organs.

1. JoLife. LUCAS™ 2 Chest Compression System Instructions for Use (100666-00E). Lund, Sweden 2009.
2. ZOLL Circulation. AutoPulse Resuscitation System Model 100 User Guide (11440-001 Rev. 3). Sunnyvale, CA 2009.