The Use of Hybrid III ATD to Assess the Effect of Body Armour upon Under-Body Blast Injuries

Thanyani Pandelani, Nicolas Newell, A Phill Pearce, Z Schutte, Dan Stinner

I. INTRODUCTION

Blast injury has been the most common cause of morbidity and mortality during the recent conflicts in Afghanistan and Iraqi [1]. In particular, body armour has been crucial in providing soldiers personal protection against the deleterious threats of improvised explosive devices [2]. In these asymmetric conflicts, specific operational requirements require soldiers to wear body armour whilst inside the vehicles. This is necessary to ensure combat readiness when dismounting the vehicle. The effect of this body armour upon injury patterns from under-body blast is not well understood.

The objective of this study was to examine the effect of body armour on the occupant response within the mounted blast environment in an effort to understand the effect of these injuries upon survivability. Determination of the extent of injury in response to blast characteristics will inform targeted mitigation and intervention in an effort to improve future survivability of blast events.

Two sets of tests were conducted. The first made use of a drop tower rig to apply a load through the seat via the pelvis, and the second sets of tests used the lower limb impactor to apply a load through the feet similar to the rapidly deforming vehicle floor seen in Under Body Blast (UBB).

II. METHODS

The Hybrid III 50th percentile Anthropomorphic Test Device (ATD) which is commonly used in tests to assess potential occupant injury due to landmine blasts inside armoured military vehicles was used for tests. ATDs are intended to provide a humanlike response in experimental scenarios. The ATD was fitted with standard body armour with a weight of 19.2 kg.

Six experiments were performed using the drop test rig, as shown in Fig.1(a), which includes a carriage, simulating the vehicle platform, which can be lifted to the desired height and then released. Six feet impact experiments were conducted using the Lower Limb Impactor (LLI). The LLI consists of a spring-powered plate that impacts the surrogate leg, as shown in Fig.1(b). The LLI allows only for vertical loaded testing using a complete ATD and is currently restricted to the seated position only.

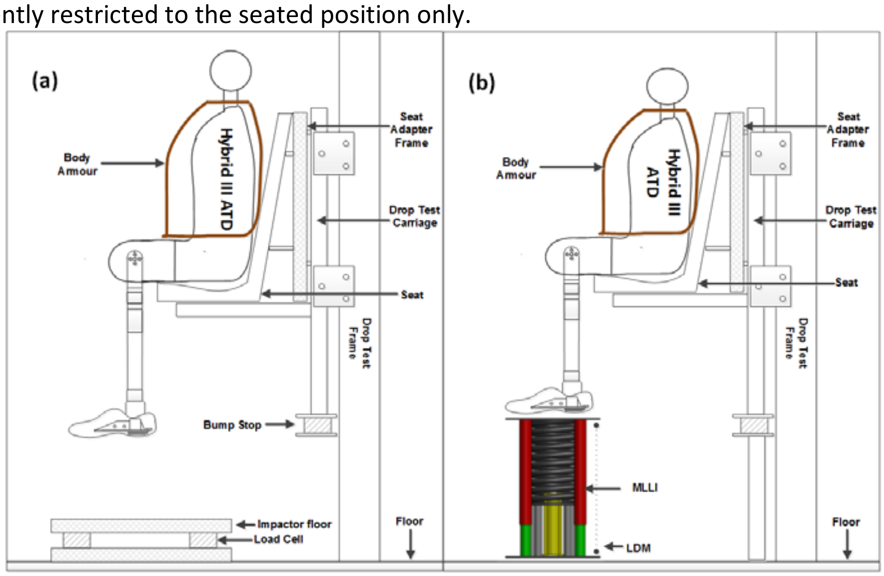

Fig. 1. Schematic set-up of the drop test rig showing the ATD seated on the steel seat (a) Drop test rig and (b) LLI.

III. INITIAL FINDINGS

The acceleration pulses applied to the carriage table of the drop tower and the LLI plate are shown Fig. 2a and Fig. 2b. The drop test rig and the LLI were tuned to have similar acceleration. This allows for comparisons of the

T. Pandelani (e-mail: t.pandelani15@imperial.ac.uk; tel: +44 (0) 7479943970) and P. Pearce are PhD students, N. Newell is a Postdoctoral Researcher and D. Stinner is Visiting Researcher at Imperial College London in the UK. Z. Schutte is a PhD student at University of Cape Town.

forces seen through both modalities as if they occurred in a single UBB in an effort to determine how each mechanism may contribute to subsequent injury.

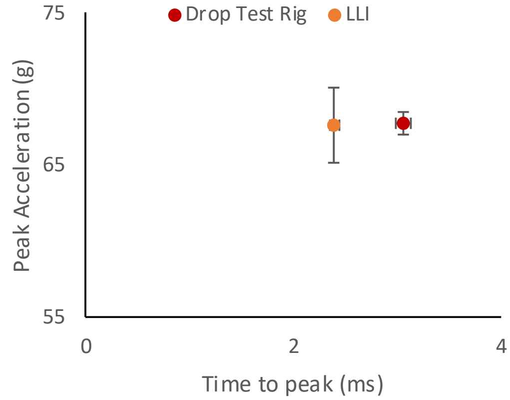

Fig. 2. Applied acceleration on the ATD from: (a) Drop test rig and (b) LLI.

The drop test rig's average acceleration was 67.4 ±0.74g with time to peak acceleration at 3.05 ±0.07 ms. The LLI average acceleration 67.6 ±2.4g with time to peak 2.4 ± 0.04 ms.

Fig. 3(a) shows the lumbar forces, Fig. 3(b) shows the femur forces and Fig. 3(c) shows the tibia forces measured from tests conducted with drop test rig and LLI with and without body armour fitted on the ATD.

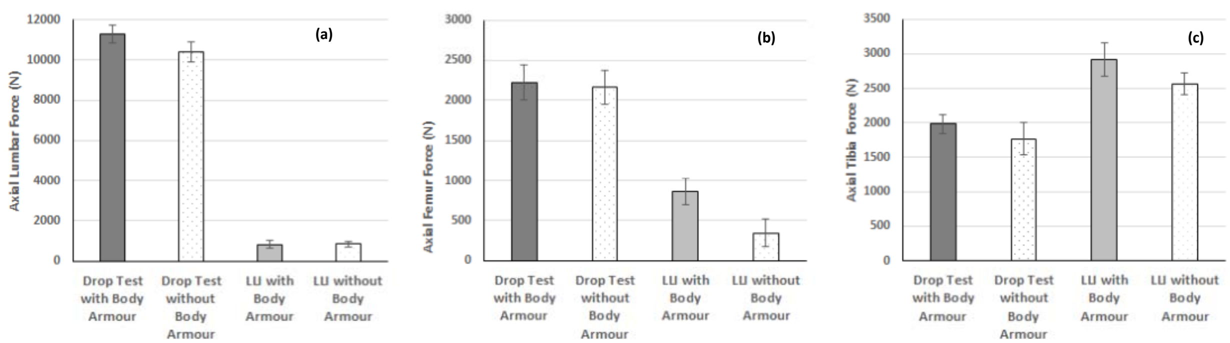

Fig. 3. (a) Lumbar, (b) femur and (c) tibia forces response from the drop test and LLI with and without body armour (average ± 1 SD are plotted)

IV. DISCUSSION

The comparison of the ATD lumbar forces with and without the body armour shows that lumbar forces from the drop tests are considerably higher than the LLI tests, which suggests that the impact from the feet has less effect on the lumbar spine. This means that the injuries to the lumbar spine are predominantly from the seat acceleration in the vehicle.

In contrast, tibia forces both with and without body armour are higher from the LLI than the drop test rig. We infer that the injuries on the lower leg are predominantly from the floor acceleration. This combination of results suggests that the load through the vehicle floor will mostly affect the lower legs while the load through the vehicle seat will affect the lumbar spine and femur.

Femoral injuries are of particular interest given that increase in femur forces with body armour are observed from both the drop test rig and the LLI. Higher forces result from the drop rig suggesting this to be the dominant mechanism of load transfer although the effect of the body armour is most pronounced in the LLI tests. The resultant pattern of forces is likely to be dependent upon the position of device detonation and proportion of load transferred through each of the two mechanisms.

V. REFERENCES

[1] Ramasamy et al, J Trauma Inj. Infect. Crit. Care, 2011.
[2] Belmont et al, J Surgical Orthopaedic Advances, 2010.