Comparison of the Temporary Cavity Properties Observed in gelatine Compared to Porcine Tissue

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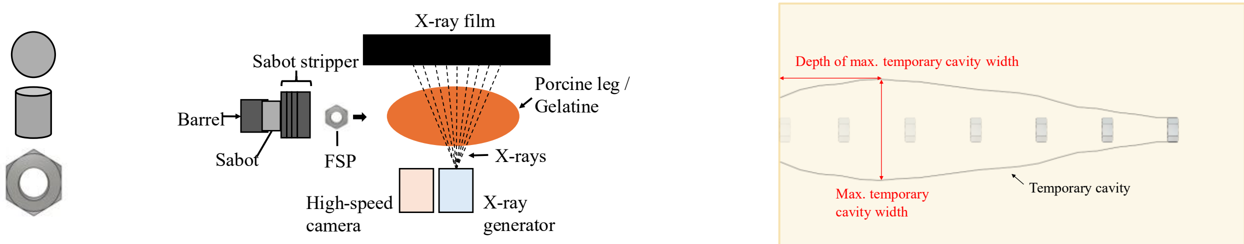
I. INTRODUCTION

Secondary blast injuries are the most common mechanism of injury from explosive devices [1]. When a fragment penetrates, it produces a temporary cavity which eventually settles to a permanent wound tract [2]. Ballistic gelatine is a widely used soft-tissue surrogate as it produces comparable depth of penetration (DoP) as porcine soft-tissue [3]. However, temporary cavity formation in gelatine has not been compared to that in muscle tissue, and DoP in gelatine has only been studied for NATO fragment-simulating projectiles (FSPs), which does not include larger and/or irregular projectiles commonly seen in terrorist attacks. This study aims to compare the temporary cavity formed in porcine tissue compared to gelatine for a variety of fragment shapes and sizes.

II. METHODS

Six hind legs of large white pigs (weighing 45-55 kg) were used, in line with previous literature [3]. The porcine legs were frozen within 24 hours of slaughter and used within a week. They were thawed overnight in a fridge at +4°C prior to testing. Ballistic gelatine (255-265 bloom) was made at 20% concentration [3]. The gelatine blocks had dimensions of 250 x 145 x 100 mm approximately and were kept at +10°C before and after each test.

A 32-mm bore gas-gun system was used to fire 0.78 g in mass and 4.5 mm in diameter right-circular cylinders (RCC), 0.51 g in mass and 5 mm in diameter ball bearings (BB) and M10 metal nuts (10.2 g in mass and 17 mm in diameter) at a range of velocities (170 – 440 m/s). The 0.78 g RCC represents the most commonly found fragment in soldiers after blast in terms of shape and estimated mass [4]. The 5-mm BB and the M10 metal nut were the main fragments in recent terrorist attacks that used an explosive device [5-6]. The M10 was secured in the required orientation within a hollow sabot using grease, while the 0.78 g RCC and 5-mm BB were supported by an aluminium front plate. A high-speed camera (Phantom VEO 710, Vision Research, USA) and a high-speed x-ray (VJ Technologies, USA) were placed at the target end of the gas gun (Fig. 1b). The footage of the cameras was used to obtain the impact velocity, maximum width of the temporary cavity and its depth from the entry point (Fig. 1c). This allowed comparison between visualisation techniques, and comparison between the gelatine and porcine target.



(a) (b)

Fig. 1: Diagram of (a) the 5-mm BB, 0.78 g right circular cylinder and M10 nut tested, from top to bottom; (b) the set-up of the target chamber of the gas-gun system, and (c) the measurements of the temporary cavity

III. INITIAL FINDINGS

Forty-six shots were analysed across the three projectiles, two visualising methods, and two targets. On average, seven and eight tests were carried out on gelatine with the high-speed camera and high-speed x-ray, respectively, and five tests carried out on the porcine sample. Some gelatine shots were viewed by one of the cameras and not both. Figure 2a shows the maximum width of the temporary cavity and Figure 2b its depth from

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point of entry for gelatine using both visualising methods. Figures 2b and 2c compare the temporary cavity in gelatine with that in porcine tissue. The data were fitted with a linear regression.

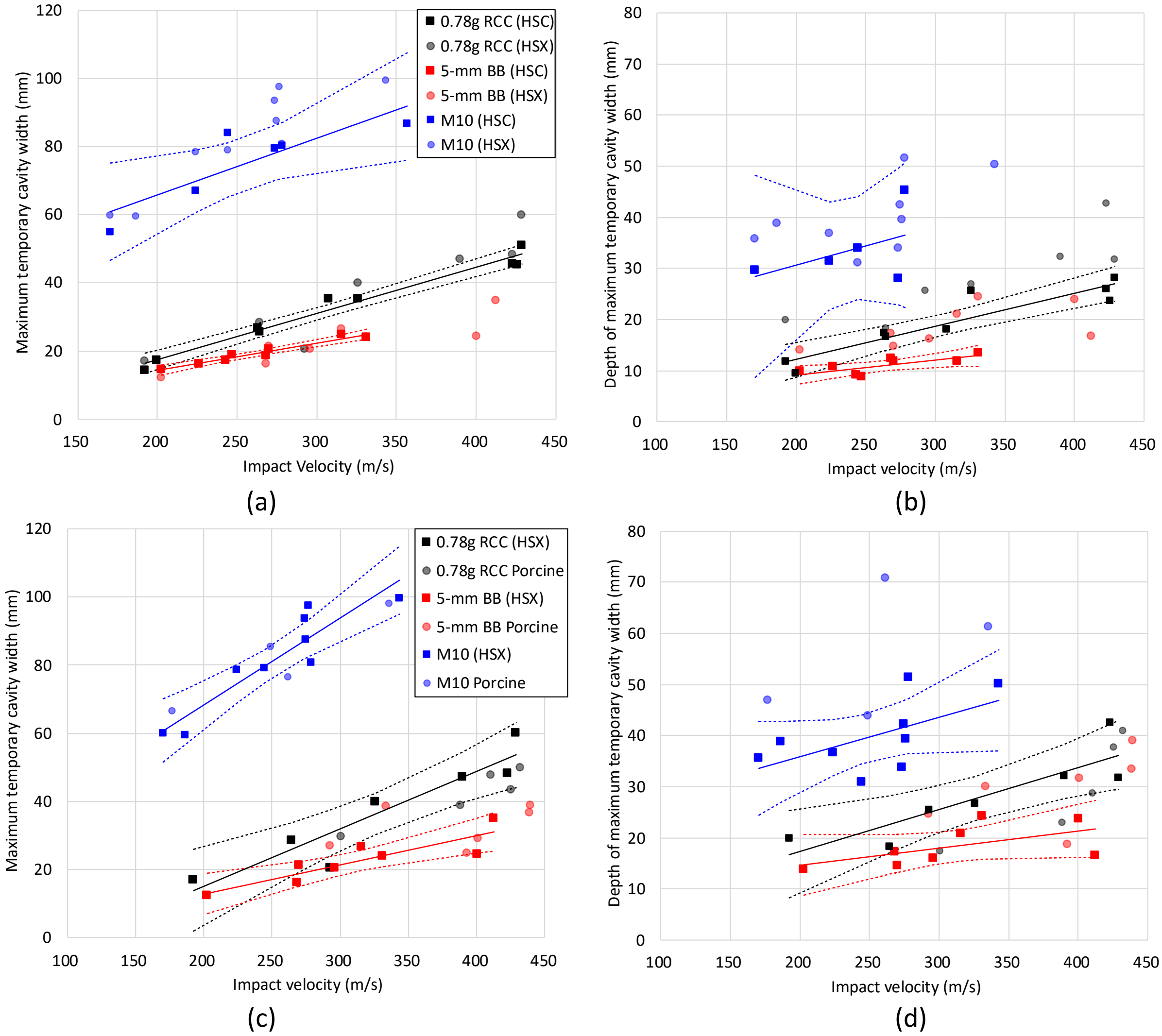

Fig. 2: (a) and (c) Maximum width, and (b) and (d) depth of the maximum width of the temporary cavity, all against impact velocity. (a) and (b) comparing the gelatine visualised with the high-speed camera (HSC) (fitted with linear regression) and the high-speed x-ray (HSX), and (c) and (d) comparing gelatine (fitted with linear regression) and porcine tissue, all for 0.78 right circular cylinder (RCC), 5-mm ball bearing (BB), and M10-nut projectiles. Dotted lines represent 95% confidence intervals.

IV. DISCUSSION

This study investigated the temporary cavity properties produced by the 0.78 g RCC, 5-mm BB and M10 nut in gelatine and porcine muscle tissue to assess the suitability of gelatine as a soft-tissue surrogate. The maximum temporary cavity width and its depth were chosen as the key metrics and were plotted against impact velocity as these relationships had the highest Pearson correlation. These results indicate that gelatine achieves similar temporary cavity widths as those seen in porcine tissue. Ongoing data processing and statistical analysis will ultimately determine how accurately gelatine replicates the temporary cavity behaviour of porcine tissue and attempt to provide a transfer function that adjusts for type of FSP.

V. REFERENCES

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