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Experimental Studies on Post-Explosion Lesions in a Model of Human Soft Tissues

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Abstract. Descriptions of blast-related injuries have long been established in the textbooks. Since, for obvious reasons, it is difficult to perform ballistic studies on human tissues, such research is usually conducted on appropriate models, i.e., gelatin blocks and soap blocks – each of these materials has distinctive properties, which make them suitable for unique applications. The work aims to present the possibilities for analyzing the effects of explosion on the human body using a ballistic soap model.

The tests performed allow to conclude that a shock wave affects the surface of the ballistic soap block, generating hemispherical craters, which begin to overlap when the distance between the explosive charge and block is reduced, until they form one semi-cylindrical hollow (when linear charge is used), which represents a temporary cavity. The results obtained allow for an assessment of the extent of post-explosion lesions.
Keywords: forensic pathology, blast-related injuries, models of human body, shock wave

1. INTRODUCTION

Descriptions of blast-related injuries have long been established in the textbooks. They differentiate primary blast-related injuries (direct result of the impact of the shock wave upon the body), secondary (penetrating and blunt trauma due to projectiles and flying debris), tertiary (effect of structural collapse of the location of the blast and physical displacement of the victim) and quaternary (fireball results and miscellaneous) [1-5].

Since, for obvious reasons, it is difficult to perform ballistic studies on human tissues, such research is usually conducted on appropriate models. Gelatin blocks and soap blocks have been well established in the literature as human tissue models – each of these materials has distinctive properties, which make them suitable for unique applications. Ballistic gelatin blocks exhibit elastic behaviour: when a projectile or a fragment passes through them, they expand and form a temporary cavity. They subsequently return to their original shape, with only the permanent canal remaining. The blocks are translucent, allowing the interaction between the projectile and block to be imaged using high-speed camera for further analysis. By contrast, ballistic soap blocks expand to leave the temporary cavity intact, which enables analysis without the use of a high-speed camera. Furthermore, these blocks are opaque, which limits the possibility of analysis with the use of such camera [6].

2. OBJECTIVE OF THE STUDY

The objective of the study was to present the possibility of testing explosion effects on the human body using a ballistic soap model.

3. MATERIAL AND METHODS

The study was conducted using ballistic soap blocks 12,5 × 25 × 40 cm produced by the Suisse company Mettler-Seifen SA / Mettler1929 International SA [7] and Finnish sheets of plastic layered PETN/RDX explosive SEMTEX® PL SE M 1 × 5 mm, weighing approximately 2 g / 25 cm [8]. The measured detonation speed of such prepared charges initiated with an ERG-type electric detonator was 8014 m/s.

The charges were placed in parallel to the block surfaces, at a distance of 0, 2.5, 5, 10 and 20 cm respectively, detonated and then the nature of soap block damage was assessed (Fig. 1).

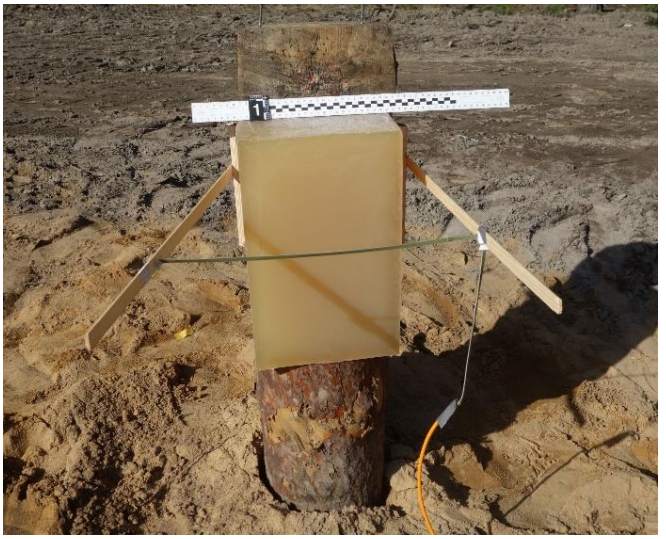

Fig. 1. Linear charge located at a distance of 20 cm from the block surface

4. RESULTS

It was found that the detonation of the explosive at a distance of 10 and 20 cm from the block surface did not cause any damage (Fig. 2 and 3). A detonation at a distance of 5 cm caused only superficial damage in the form of serially arranged, partially overlapping hemispherical craters, with a diameter from several millimeters to a maximum of 1 cm (Fig. 4). A detonation at a distance of 2.5 cm caused the formation of a semi-cylindrical hollow with a diameter of about 2 cm, whose structure showed that it consisted of numerous overlapping hemispherical craters with a morphology similar to those created during the detonation at a distance of 5 cm (Fig. 5). The last experiment, i.e., detonation at a distance of 0 cm (Semtex® strip applied to the block), caused the formation of a similar semi-cylindrical hollow, but with a diameter of about 4 cm and a relatively smooth surface (Fig. 6 and 7). In addition, detonation of all charges resulted in sooting of the block, i.e., the closer the charge, the larger the sooting.

Fig. 2. No damage (sooting only) following an explosion at a distance of 20 cm

Fig. 3. No damage (sooting only) following an explosion at a distance of 10 cm

Fig. 4. Damage after a linear charge explosion at a distance of 5 cm

Fig. 5. Damage after a linear charge explosion at a distance of 2.5 cm

Fig. 6. Damage after a linear charge explosion at a distance of 0 cm

Fig. 7. Damage after a linear charge explosion at a distance of 0 cm.

5. CONCLUSIONS

The tests performed allow to conclude that a shock wave affects the surface of the ballistic soap block, generating hemispherical lesions, which begin to overlap when the distance between the explosive charge and block is reduced, until they form one semicolumnar lesion (when linear charge is used). It should be remembered that, due to the nature of the blocks, the damage represents a temporary cavity rather than a permanent one. In other words, the image on the surface of the human body will differ from those obtained from the experiments, and the results obtained facilitate estimation of the extent of post-explosion damage.

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Badania doświadczalne powybuchowych uszkodzeń modelu tkanek miękkich ciała ludzkiego

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Streszczenie. We współczesnym piśmiennictwie tematycznym istnieje zgodność co do rodzajów obrażeń ciała będących skutkiem wybuchu. Ponieważ badania balistyczne tkanek ludzkich z oczywistych względów są trudne do przeprowadzenia, zazwyczaj prowadzi się je na odpowiednich modelach, tj. blokach żelatynowych i blokach mydlanych, których właściwości są jednak różne i przez to ich zastosowania są inne. Celem pracy było przedstawienie możliwości badania skutków wybuchu na ciało ludzkie przy pomocy modelu z mydła balistycznego. Uzyskane wyniki pozwalają na wyciągnięcie wniosku, że fala uderzeniowa działa na powierzchnię takiego bloku generując uszkodzenia o półkulistym kształcie, które przy zmniejszaniu się odległości od ładunku zaczynają się nakładać na siebie, aż do całkowitego zlania się w jedno uszkodzenie o półwalcowatym kształcie (przy ładunku liniowym), co odwzorowuje jamę tymczasową. Uzyskane wyniki pozwalają na oszacowanie rozległości uszkodzeń powybuchowych.

Słowa kluczowe: medycyna sądowa, obrażenia powybuchowe, modele tkanek ludzkich, fala uderzeniowa