Wound ballistics and the concept of “death by shock”

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The term “shock” is considered by many to be an important factor when comparing the killing power of different cartridges and bullet types. Manufacturers of hunting ammunition commonly declare that their bullets deliver tremendous shock upon impact and therefore have superior killing power. Here we discuss this concept and conclude that there is no instant shock effect in an animal hit by a bullet.

When comparing effectiveness of different types of bullets wound ballistics must be considered. Wound ballistics is defined as the theory of interactions between a penetrating projectile and living tissue. Wound ballistics includes only the primary (immediate) effects of projectile penetration such as the wound, cavitations and effects on nerves. Secondary effects, including blood loss, reduced blood pressure and decreased tissue oxygen delivery occur later.

Although a shock wave is generated when a high speed projectile penetrates tissue, it is necessary to make a distinction between shock and pressure waves. Both waves occur when a projectile penetrates tissue. A shock wave lasts in the order of microseconds, while a pressure wave sustains for milliseconds. A shock wave is a type of sound wave (acoustic compression wave) that passes through the body at a speed of about 1500 m/s. In wound ballistics, the shock wave is generated by the projectile (as it ruptures tissue) and propagates in front of the penetrating projectile. No substance is transported by such a wave. In contrast, a pressure wave moves body tissue and therefore generates pressure changes as it propagates. A high speed penetrating projectile dislodges and accelerates elastic tissue in a direction perpendicularly to its forward motion creating a temporary cavitation behind the projectile that is much larger than the projectile’s diameter. Thus, the forces of inertia on the tissue create a pressure wave that propagates throughout the whole body of an animal. During this process, tissue is compressed and stretched but strain energy rapidly forces the elastic tissue back to approximately the original position.

So, how dangerous is this “shock” wave? There is a misconception that an individual could instantly die from a high-speed bullet even if it barely touches the body. However, no scientific proof for such instant shock-effects is ever described.

A penetrating bullet will cause a shock wave to propagate throughout the body. Nerves are stimulated by shock waves and respond with increasing amplitude until they are fully stimulated and cannot be stimulated further. However, nerves respond similarly whether the stimulus is a shock wave or an external pressure. The target organ influenced by the nerve impulse cannot tell whether the received impulse originated from internal or external stimulation. It is therefore unlikely that an internal shock wave would generate a different reaction than an external counterpart. A good example is that acoustic waves (with five times the intensity of a shock wave generated by a bullet) can be used to break up kidney stones in non-invasive procedures.

Body cells are also affected by shock waves and are damaged if bullet velocities are high enough. However, cell damage occurs many hours after the passage of the bullet and the

effect is therefore not instantaneous. However, the mechanisms behind this cell damage are not yet understood.

The misconception of instant death by shock has arisen because animals frequently are instantly knocked down when hit by a bullet. This might happen with a central nervous system (CNS) impact causing a total loss of motor function or as a result of mass impact forces due to the formation of the temporary cavity. The rapid displacement of tissue mass can brake bones or affect CNS and other sensitive organs so that the animal instantly faints and falls like hit by a sledgehammer. If the impact causes a lethal bleeding the animal will die before it regains consciousness and the hunter is left with the impression that the animal died by some shock effect. A bullet fragment might also give the same reaction. The instant knock down effect is therefore the result of a pure mechanical interaction.

Thus, we are left with two possible causes of death as a result of a penetrating projectile (bullet or arrow):

1. Collapse of the circulatory system due to loss of blood
2. CNS trauma causing total loss of motor functions

The medical term “shock” represents a state of impaired oxygen delivery to the tissues of the body as a result of reduced blood flow. Shock is never instant and develops over time. Thus all animals belonging to category 1 will ultimately go into shock and die when blood loss, blood pressure and oxygen delivery have reached critical levels. But this is no instant event and it might take several seconds to some minutes before the animal is grounded.

We hope that this discussion will help to clarify some misinterpretations related to the concept of so-called death by shock.

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