Missile Injuries

High velocity missile wounding using military projectiles[1]

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This paper discusses high velocity missile wounding caused by military projectiles. For the purpose of this paper, military projectiles considered will be those of eight mm diameter or less, fired from small arms like rifles, sub-machine guns and machine guns. High velocity is defined as speed in excess of 750 m sec[1].

EXPLANATION OF BALLISTIC TERMS

Rifling

Rifling is the grooves that are machined inside a barrel, designed to impart a spin on the projectile as it leaves the barrel. Rifling imparts a gyroscopic effect on the projectile, giving it stability in the air. The tighter the twist of the rifling, the greater the stability of the projectile, since the rate of spin is faster. A one-in-seven twist is lighter than a one-in-twelve twist.

Bullet Construction

There arc two main types of bullet construction in military projectiles. These are single and dual cores. The single core uses lead, whereas dual core uses a combination of lead and another material, usually steel. Projectiles using lead at the rear have improved stability in flight due to the rear centre of gravity. The jacket thickness is also important. The thicker the jacket, the less likely will the bullet fragment on impact with human tissue. Under international law, all military projectiles must have a jacket covering the nose and sides, hence the term 'full metal jacket'

Trajectory

The trajectory of a projectile is the path the projectile travels through the air until it impacts against a surface. The angle that a projectile impacts upon a body is important in wound ballistics. The greater the impact angle, the more likely will the projectile pass through the body tangentially.

Drag

Drag is the resistance to movement on an object in a medium. The greater the density of the medium, the greater the drag. A projectile upon entering human soft tissue goes from a medium (air) of 1.2 kg m^3 to one of 1,000 to 1,100 kg m^3.

Yaw

Yaw is the deviation of a projectile in its longitudinal axis from the straight line of flight. At close range, under 30 m, high velocity projectiles exhibit a large amount of yaw as the stability effect of rifling has yet to start. Due to insufficient twist, some projectiles never become stable in flight, and yaw continually until impact. Yawing determines the surface area of the projectile upon impact.

Tumbling

Tumbling is the forward rotation around the centre of gravity of a projectile. Tumbling is determined by a projectile's yawing, drag and design. A greater angle of yaw increases the drag and promotes quicker tumbling. Dual cores by their nature cause quicker tumbling. Jacket construction also contributes to quicker yawing, as a projectile may be more likely to break up upon impact.

THE MECHANICS OF WOUNDING

The Hague Convention of 1899 stated that: 'the contracting parties agree to abstain from the use of bullets which expand or flatten easily in the human body'.

This was subsequently written into the 1949 Geneva Convention. To adhere to this, all military projectiles became fully jacketed, and are so to this day. The exception to this is shotgun rounds, which are able to be legally used without a jacket.

When the Hague Convention was drafted, nearly all nations went from round nosed to spitzer projectiles, that is, ones with pointed tips. Round nosed bullets have poor long range ballistics due to drag, but excellent penetration on soft tissue as they have minimal yaw, thus also having poor tumbling characteristics. Spitzer bullets exhibit better yawing, thus better tumbling effects on soft tissue.

In all high velocity missile wounding, the two major mechanisms of wounding are cavitation and the effect of secondary missiles.

1. Andrew M. High velocity missile wounding using military projectiles. Aust Mil Med 1994; 3(2):13-14.

Cavitation

There are two types of cavitation, permanent and temporary.

The permanent cavity is tissue crushed during a missile's travel in the body. This is determined by tumbling, bullet deformation, secondary missiles and the missile's weight upon impact. The greater the penetration and surface area of the missile, the larger the permanent cavity.

The temporary cavity is the momentary stretch or acceleration of tissue away from the bullet track. It might be thought of as blunt trauma surrounding a portion of a missile's travel in soft tissue. Elastic tissue like lungs, bowel wall and muscle tolerate stretch much better than non-elastic solid organs like liver, kidneys or a full bladder.

Secondary Missiles

Secondary missiles are objects which perforate tissue away from the main wound track. These fragments increase the amount of blood vessels injured, tissue perforated and organs damaged. Examples of secondary missiles are bone splinters, missile fragments, zips, buckles, buttons and pieces of hard body armour.

Projectiles can be designed to break up or fragment. Projectiles such as the German 7.62 x 51 mm NATO bullet, and its Swedish counterpart of the same calibre, have a deliberately thin jacket when compared to the United States equivalent. The Australian 7.62 mm round has a thick jacket similar to the US bullet.

By incorporating a lead core in the rear of a dual core projectile, it is made stable in flight. Upon hitting tissue, however, it quickly tumbles due to its rear centre of gravity. Dual core rounds also tend to break up at the join of the cores, causing greater wounding with two main wound channels and numerous smaller ones.

Historically, wound ballistic studies have over-rated the temporary cavity at the expense of the permanent cavity and secondary missiles. There arc many variables that affect the temporary cavity size and its effects. These need to be taken into consideration when studying reports about the effects of missiles fired into gelatine blocks simulating human tissue.

The effects of secondary missiles and temporary cavities arc synergistic in high velocity missile wounds. Secondary missiles cause multiple tissue perforations away from the wound track, which are then stretched by the temporary cavity. The weakened tissue splits in many places and pieces of muscle become detached. This creates a larger permanent cavity. At velocities over 900 m s^1, in conjunction with the temporary cavity, secondary missiles cause explosive type wounds, even if bone is not struck.

A large, heavy, slow moving missile will have similar effects to a high velocity round, excepting that the permanent cavity is due to the missile's surface area and weight, not its velocity.

WOUNDING EFFECTS OF MILITARY PROJECTILES

To establish the effects of missiles, the then Colonel Fackler at the United States Army Letterman Army Institute of Research, established the Military Trauma Research Division in 1981. He developed the Wound Profile. This is a method that allows tissue disruption by missiles in soft tissue to be presented graphically. This part of the paper has been written using notes and wound profiles provided by Dr Fackler when he was in the US Army,

Dr Fackler's work has removed many of the misconceptions of wound ballistics. The wound profile enables the physician and researcher to establish why missiles behave differently at different depths of penetration, without bias. The following wound profiles describe the military projectiles most likely to be encountered. They describe the effects of projectiles fired three metres from a gelatine block.

The 7.62 mm NATO projectile, as used by the Australian Defence Force, and the Russian 7.62 M43 projectile as used in the SKS and AK 47 family of assault rifles have similar wound profiles. The NATO bullet yaws and causes a large temporary cavity and a medium sized permanent cavity, and ends up travelling backwards. The Russian 7.62 machine gun and sniper projectile is similar, yawing twice with a small permanent cavity initially, and a larger one after it.

Both projectiles only tumble deep inside the body if soft tissue is involved, and thus cause uncomplicated wounds in most cases of soft tissue injury. In many instances, the Russian projectile only causes wounds that resemble much lower velocity hand gun wounds. Both the NATO and Russian projectiles have thick jackets and have a forward centre of gravity which gives them stability in soft tissue.

Comparing the Russian M193 and NATO 5.56 mm projectiles, the M193 yaws at 90 degrees early in its travel, flattens at the tip, and breaks at the cannelure. The rear of the projectile breaks into multiple fragments. The NATO 5.56 projectile's tip does not deform, but separates from the rear lead core. This creates two deep wound channels and multiple fragments. Both bullets will break up on contact with soft tissue at up to 200 metres.

The 12-gauge solid slug and 12-gauge number 4 buckshot produce the most devastating close range small arms wounds. In each case the permanent cavity through soft tissue is 6 cm square in cross sectional area. The tissue destruction produced by buckshot is massive when compared to other small arms projectiles, despite its low velocity, and is a good example of multiple projectile paths in a small area.

CONCLUSION

Much can be learnt of the likely nature and extent of individual wounds by studying experimentally the effects of various types of projectiles impacting upon synthetic tissue substances. Detailed graphic analysis of these effects can assist in predicting the threat to troops in an operational environment.