Guest Editorial

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The lost race

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Gunshot wound to the head is one of the most devastating injuries in humans. It is difficult to imagine the injury carrying more devastating potential than the gunshot brain injury does. For the centuries the penetrating head injuries were considered incurable. It was not until the 1870's and the advent of antiseptic and aseptic surgery that the intradural space was explored surgically. The mortality rate of the penetrating head injuries in Homer's era around 700 B.C. was estimated to be about 76%, in the Crimean war it was 73.9%, while in the American Civil war, the mortality rate for those wounds was 71,7% [1,2,3]. Thanks to the Cushing's more vigorous measures taken to treat the patients with dural penetration including a primary watertight closure of the dural lacerations, the mortality rate was reduced from 54% in the early stage of WWI to 29% in the later stage. With the advent of antibiotics in WW II the rate dropped to 14%. In the Korean and Vietnam wars it further decreased to 10 % [2,4,5,6].

In the wars fought afterwards the mortality increased to the rate of 15% in Iraq-Iran war, while in Lebanon war, in spite of the routine use of CT scanning for the evaluation of the injured, the mortality further increased to the rate of 26% [7,8,9,10]. The Lebanon experience revealed that CT scanning, as an important technical achievement, did not affect the overall result since the mortality rate was even higher than in Vietnam War when CT was not available. However, in the series of 162 patients injured in the Yugoslav Civil War the mortality rate of the injured with bullets was 32%, and with shrapnells 10.6% [11].

In this series, 32% of the injured sustained the bullet injuries while in the Vietnam war the bullet injuries were noted in 16.1%, and in the Lebanon war in 13 % of cases [6,8,11]. This data might reflect the more prevalent use of snipers in Yugoslav conflict. We believe that the higher percent of the bullet injuries account for the higher mortality rate as well. The overall mortality from different battlefields of the disintegration agony of Yugoslavia was 25% [12,13] (Fig 1) .

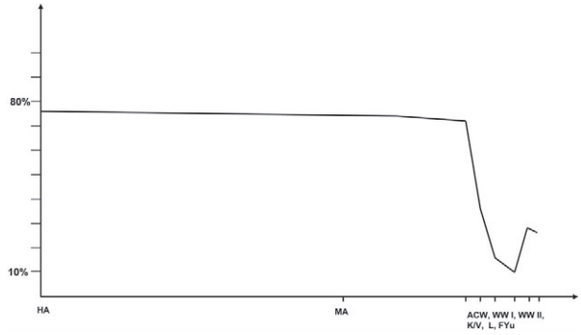

Fig 1: The mortality rate from the war head injuries through the history: HA – Homer's age, MA - Middle age, ACW – American Civil War, WWI – World War I, WWII – World War II, K/V – Korean and Vietnam War, L – Lebanon War, FYu – War in former Yugoslavia

Looking retrospectively recent decades have obviously seen so many advancements in the field of medical science which particularly relate to the treatment of the injured such as intensive care of the injured with frequent use of the tracheotomy, medical and surgical control of increased intracranial hypertension, advances anesthesia, CT scanning, magnetic resonance imaging etc.

The strategy for the debridement of the craniocerebral penetrating injury evolved to the following goals of surgery: evacuation of intracranial hemathoma and deranged brain tissue with accessible bone and/or metallic fragments along the path of the missile, primary dural and scalp watertight closure. Thus, the debridement technique deals primarily with the missile path [14].

All of those achievements came to the day light alongside with the improvements in technology of the warfare sciences, aimed at the development of as much deadly weapons as possible. Said in simple words, on both sides of the racing line there are the scientists, ones searching for the survival of the injured, the others searching for ultimate death - the death at the moment of impact, if possible!

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Who is winning this race for life or death?

In the early development of the fire weapons, destruction of the brain was caused mainly by a bullet that crushes tissue directly in its path, while in modern era, the brain destruction proved to be more extensive involving the brain regions distant from the projectile path. The destructive capacity of the bullet itself has been shown to be related to the kinetic energy deposited on the target organ. The energy release and the patterns of damage depend primarily on the speed of the bullet. Projectiles traveling at the speed of less than 2000 feet/sec are considered low velocity missiles, while those traveling above this speed are termed high velocity missiles[15]. The kinetic energy contained in the missile increases directly with the square of its velocity ($KE=mV^2/2$). In the 60s, the ammunition introduced in the military service and used in war included the M-16, 223 Remington bullet with 56 grains in weight, caliber 5.56 mm, muzzle velocity of 3300 ft/sec and energy 1300 ft/lb, and the 7.62 mm AK-47 with bullet weight 122 grains, velocity of 2400 ft/sec and energy of 1500 ft/lb [3].

This ammunition brings new insight into the war gunshot injuries. The energy amount of those bullets is almost 4 or 5 times greater than the energy of a bullet fired, for instance, from Luger 9 mm handgun, which is 115 grains in weight, with speed of 1140 ft/sec and energy of 330 ft/lb [3].

During the treatment of gunshot injuries inflicted during the Yugoslav war, we noted that the direct hit of high-velocity bullet caused an injury resembling to a form of intracranial explosion. In the theory of terminal ballistic, this explosion is described as the hydrodynamic strike producing shock and cavitation waves in the brain tissue that ensures the damage distant from the bullet trajectory. The brain damage resulting from a high-velocity missile is in the sharp contrast with the skull injuries noted on the skulls in so called "Skull Tower" (http://en.wikipedia.org/wiki/Skull_Tower.) built in central Serbia in 1809 after the Chegar Hill battle, when skulls of 952 killed Serbian soldiers were embedded in the walls of this unique tower. The 58 skulls remained until the present time. The uniformly small bone defects resulting from the handgun projectile impact could be noted on those skulls sustained gunshot injuries. The skull bone trauma is much smaller as compared to multicompound skull fractures from the hydrodynamic implosion caused by a high-velocity missile of modern times. (Fig 2: a, b) Penetration of a high velocity projectile generates high pressure wave that displaced tissue away from the missile trajectory. That pressure wave described often results in the instantaneous death at the scene due to the brain stem incarceration.

Fig 2 a: The Skull Tower

Fig 2 b: The skull of the injured who sustained cross and cross gunshot wound from the close distance. Note the black colored ring of gunpowder in the bone at the bullet entry.

It was shown that more kinetic energy is transferred to surrounding brain where missile undergoes greatest slowing. The bullets with greater specific kinetic energy i.e. with small mass and surface space display the greatest slowing on the target because the amount of specific kinetic energy is oppositely proportional to the projectile surface space (specific kinetic energy = kinetic energy/ surface space of the bullet).

The cavity created by the kinetic energy transfer displaces the brain tissue radially away from the bullet trajectory pressing it to the rigid skull wall. Afterwards the brain tissue collapses into the cavity, and this tissue oscillations around the missile path may be repeted several times creating the distracting-shearing force that derange brain tissue well away from the missile trajectory. Thus, the energy deposited by a low weight and high velocity missile is capable of causing severe and widespread axonal damage irrespective of trajectory. Higher the velocity, greater the energy per unit of time and larger the temporary cavitation, with damage not only along the path of the missile, but in areas remote from this path. Thereafter, the structural damage of the brain tissue could not be sufficiently addressed by the surgical wound debridement. The result of surgery is limited by the pathophysiology of the hydrodynamic strike.

The increased rate of the mortality from craniocerebral penetrating injuries, in spite of the improved medical and surgical treatment, might be explained with the increased hospital mortality rate due to the death of the most severely injured who were evacuated, without any chances for survival. However, the other important variable could not be excluded: the improved medical practice and strategy along with prompt evacuation is not sufficient to cope with advanced war technology. The ammunition developed on the basis of terminal ballistic theory of energy transfer significantly lowered chances for the successful treatment of the patients suffering from injuries caused by those projectiles.

The higher mortality rate coincides with the introduction of high speed bullets into the military use. The mortality rate just reflects the damage capacity of this ammunition.

We believe that development of the ammunition based on specific kinetic energy transfer to the tissue on target organ has marked the line behind which medical community starts losing its race for life.

It is well possible that the race for survival has been definitively lost.

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