The Electromagnetic Cause of Shell Shock

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Abstract—The pathology of shell shock, contemporaneously grouped with post-traumatic stress disorder, has been identified by researchers. The brain injury occurs primarily in the frontal lobes and has a "distinctive honeycomb pattern of broken and swollen nerve fibers." The characteristics of the head protection used by soldiers can explain why the particular shell shock brain injury has an inordinate prevalence today, but without the massive artillery barrages. Every munitions explosion emits a broadband pulse of electromagnetic energy and this energy can cause cellular level heating damage. Kevlar helmets provide no protection from an electromagnetic pulse.

I. Introduction

"The mystery of shellshock solved: Scientists identify the unique brain injury caused by war."[1] The description of the brain injury in the article is provided in one paragraph, "*Described as a 'distinctive honeycomb pattern of broken and swollen nerve fibres', the injuries were not the same as those found in car crash and drug overdose victims, or sufferers of punch-drunk syndrome, which is caused by repeated blows to the head.*" Another article stated, "*Scientists have discovered what a traumatic brain injury, or TBI, suffered by a quarter-million combat veterans of Iraq and Afghanistan looks like, and it's unlike anything they've seen before: a honeycomb pattern of broken connections, primarily in the frontal lobes, our emotional control center and the seat of our personality*."[2]

Both articles were summarizing a Jan. 2015 news release from John Hopkins School of Medicine (JHM).[3] That news release was a summarization of an article published in Acta Neuropathologica Communications in Nov. 2014.[4] The introduction of the article stated, "Blast injury to brain, a hundred-year old problem with poorly characterized neuropathology, has resurfaced as health concern in recent deployments in Iraq and Afghanistan." The researchers identified the pathological characteristics of the brain damage, but did not speculate on the specific mechanism that is causing the unique damage.

In World War I (WW1), the massive artillery barrages exposed soldiers to nearby munitions explosions and many of those that survived the blast damage, with no obvious cranial injuries, afterward displayed erratic emotional behavior. The term *shell shock* was coined to describe the outward characteristics. The term *shell shock* was not used in World War II (WW2) and the Korean War; the terminology was changed to *combat* or *battle fatigue*. Vietnam veterans, and those thereafter, exhibiting the same behavior as those suffering from *shell shock* were classified as having *post-traumatic stress disorder* (PTSD).

The first report using the term *shell shock* was in 1916. The term *shell shock* was banned in the UK after WW1. A good summary of the history of *shell shock*, and why the term was banned, is provided in the article titled, "Traumatic Brain Injury, Shell Shock, and Posttraumatic Stress Disorder in the Miltary-Past, Present and Future."[5]

From an electrical engineers perspective, the honeycomb pattern damage in the frontal lobes of the brain suggests the cause for the damage is exposure to a high intensity electromagnetic (EM) pulse (EMP).

II. Cranial Protection

When warfare began to be fought with bullets, the metal head and body protection used for protection from swords, lances, arrows and other weapons was deemed an impediment, as it didn't stop bullets. In WW1, the use of artillery produced an inordinate amount of head injuries from shrapnel. The French developed the M15 Adrian helmet in 1915 and the British developed the Brodie helmet; the similar design M-1917 was issued to U.S. troops. These helmets covered the top cranial area and the flared rim did not extend below the top of the ear lobe and much of the forehead was exposed. The Germans developed and issued the Stahlhelm in 1916 for the same reason, an inordinate number of head injuries. Each of the helmets differed in their steel composition, some being more penetration resistant.

The steel U.S. M1 helmet was adopted in 1941, and it covered a larger percentage of the cranial area in the front, and the sides extended downward about halfway over the ear. The non-steel Kevlar helmet was adopted by the U.S. in the mid-1980s. The Kevlar has superior ballistic performance over steel and its size protects a greater percentage of the cranial area from ballistic injuries.

A high intensity broadband EMP will not readily penetrate steel, but the Kevlar helmet will provide essentially no protection from an EMP that has wavelengths that can cause serious internal tissue damage.

III. Electromagnetic Radiation From Chemical Explosions

"*The emission of electromagnetic radiation from a chemical explosion is well established.*"[6] That quote is from a LANL report, but many may conclude that the bright flash and heat felt are the extent of the EM radiation. The range of frequencies being produced by an explosion are very broad. The LANL report summarized reports from 1954 to 1993 and the summary of the **spectrum** section stated, "Quoted frequency ranges vary from 1 Hz to an excess of 100 MHz. Possibly the spectrum shifts to lower frequencies with increasing mass. Theoretically, the spectrum should broaden to higher frequencies as the detonation time is shortened."

The Journal of Radioelectronics (JRE) is a Russian Academy of Sciences report. The JRE report summarized research on the EM emissions from explosives, 1940 up to 1999.[7] The JRE report did not summarize the spectrum identified, but the measured frequencies noted in the report ranged from 14 MHz up to 100 GHz. The reported frequencies became higher and higher as measurement equipment became available that could detect and measure these frequencies. The JRE report was focused on microwave frequencies and referred to a specific reference for lower frequencies. In regards to the microwave radiation, the JRE report provided this statement, "*The intensity of this radiation much surpasses intensity of thermal radiation.*" The report also stated, "*The larger the explosion the higher EMP intensity.*"

The LANL and JRE reports did not mention the possible mixing of various frequencies, additive and subtractive. The additive results could have much higher frequencies, possibly higher than could be detected by the measurement instruments available over a decade ago. The LANL and JRE reports were not considering human exposure, thus they did not consider the attentuation and frequency lowering effect when an EM wave passes through a material that has an index of refraction greater than one.

The scaling for the damaged areas in the brain shown in ref. (4) provides sizes from 100 to 10 µm, which would correspond to wavelengths of frequencies from 3,000 GHz to 30,000 GHz. The infrared spectrum extends from 300 GHz to 430 THz. The frequencies in the EMP being produced by a chemical explosion have a range of wavelengths that will allow efficient EM energy transfer to many conducting structures in the human body.

"*In the brief instant of a high-explosive detonation, some remarkable events take place: the shock wave produces pressure up to 500,000 times that of Earth's atmosphere, the detonation wave travels as fast as 10 kilometers per second, temperatures can soar to 5,500 kelvins, and power approaches 20 billion watts per square centimeter.*"[8] That statement is from a 1999 Lawrence Livermore National Laboratories (LLNL) internet page. Because there is so much power produced, it is important that the EM intensities are quantified in the various EM spectrum ranges for different types of explosives, including the Improvised Explosive Device (IED).

It is now known that high altitude electrical discharges can produce both gamma and x rays.[9] It was not noted in the reports reviewed whether gamma and x ray detectors were used during the explosion tests.

IV. Electromagnetic Spectrum and Human Exposure

We are constantly exposed to a broad spectrum of EM radiation from planetary, solar system, galactic and cosmic sources. The EM spectrum covers frequencies from very low to very high frequencies that extend well above the optical spectral range. With the advent of man-made EM sources, we are now exposed to many local EM sources and the effects these have on the human body are not fully understood.[10]

Our human sensory systems can directly detect the presence of EM radiation in the optical range and the invisible infrared and ultraviolet frequencies when they produce secondary effects, which are surface heating and sunburn. The effects of long term cranial exposure to various levels of EM emissions are being studied, but none of the studies involve very high magnitude EM sources, as it is already known these can cause severe internal body damage by heating.

When an EM wave has a wavelength that is matched to the size of a conducting structure, the energy of the wave will be efficiently transferred. Just a close match between the wavelength and the conducting structure size can transfer some power. A human body contains many different sizes of conducting structures, primarily water based. The present concern about cell phones involve two frequencies, 900 MHz and 1900 MHz. Cell phones produce a very lower power level, but it is the close proximity of the EM radiation to body tissue that creates concern. Most artificially produced EM radiation decays with distance by $1/r^2$, but EM wave *near field* issues come into play when within two wavelengths of an EM source. *Near field* issues involve EM field components that do not decay with distance by $1/r^2$. With cell phones, users not using the speakerphone feature will always be in the *near field*. Very low power levels can damage mammalian brain tissue.[11] Those familiar with the damage shown in ref. (11) can determine whether it is similar to the "honeycomb" damage shown in ref. (4).

The acronym EMF, seen in some reports, refers to *electric and magnetic fields*, and is used in the guidelines that limit human exposure to these fields; the *specific absorption rate* (SAR) regulations.[12] The SAR regulations are focused on avoiding "tissue heating."

EM energy can come in non-ionizing and ionizing form. The ionizing form is that produced from sources that produce extremely high frequency EM radiation, such as gamma and x rays. If the magnitude of EM radiation is high enough, even though it is does not have the high frequency of an ionizing emission, it can produce major damage to conducting body structures. Microwave ovens use a frequency of 2450 MHz or 2.450 GHz. That frequency is resonant to a characteristic of the water molecule and causes heating, but ionized water can be heated by the electric current produced by EM waves, which is what is happening to brain tissue with prolonged exposure to cell phone emissions. The JRE report noted frequencies that would cover the 2.450 GHz frequency. A question that can be asked is, "What EM intensity would be required to raise the temperature of the fluids in the brain axonal structures to a level that would produce the damage shown in the ref (4) report?" Water can be heated at the 2.450 GHz frequency, but a conducting structure in the brain that matches a particular EM wavelength could absorb power very efficiently and cause heating damage at lower power levels.

The JRE report emphasized the electron contribution to producing EM waves at microwave frequencies. "At higher frequencies the microwave radiation itself was found out, when the field decreases in inverse proportion to distance (~R-1)." This is significant, as it states the EM radiation does not have spherical decay, $1/r^2$, which is what would occur if the EM radiation polarization was transverse to the axis of propagation. The SAR regulations are based upon exposures to EM radiation that decays with distance by $1/r^2$ rather than 1/r. Ions and electrons are major products of the explosion. Nothing was mentioned in the LANL, JRE or LLNL reports on ion contribution to the EMP.

It cannot be excluded that nerve fiber structures in other parts of the body are being damaged by an EMP where current non-invasive medical technology can not find any direct physical trauma evidence. This could be related to OEF/OIF veterans' experiences with chronic pain.[13]

Soldiers that are *breachers* and law enforcement SWAT teams that use *flash-bang* devices are exposed to repeated exposure to low-level blasts (LLB).[14] There are on-going studies of the cognitive functions of individuals involved as breachers.[15] Cognitive impairments have been identified in a New Zealand study of breachers.[16] The action being taken to mitigate the effects of LLBs are focused on reducing exposure to the concussion effect of an explosion. Getting further away from the LLB will reduce the concussion and EMP exposure, but that lengthens the time to take advantage of the purpose of the LLB. The EM spectral characteristics of various LLB devices are not known.

V. Summary

An explosion EMP produces EM frequencies from 1 Hz to the optical frequencies. The upper limit is unknown and the current gaps in the high microwave spectrum to the infrared is probably due to measurement instrument limitations.

With a quarter million TBI victims, and counting, it is imperative that the EM signatures and spectral intensities of the EMPs produced by various munitions explosions be fully identified, regardless of the technical difficulty. This should include gamma and x ray detectors. This information will identify the needed EMP protection

Military ballistic protection head gear should provide protection from the EMPs produced by nearby munition explosions.

Breachers and SWAT team members should have breacher shields and head protection that protects them from EMPs. There should be an exposure limit until such time full body protection can be provided from an EMP.

It should not be difficult to prove that mammalian brains and nerve structures in other parts of the body are being damaged by the EMP from an explosion; they are already being damaged by EM radiation from other sources.

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