# Sinister shock: Researcher studies how explosive shock waves harm the brain

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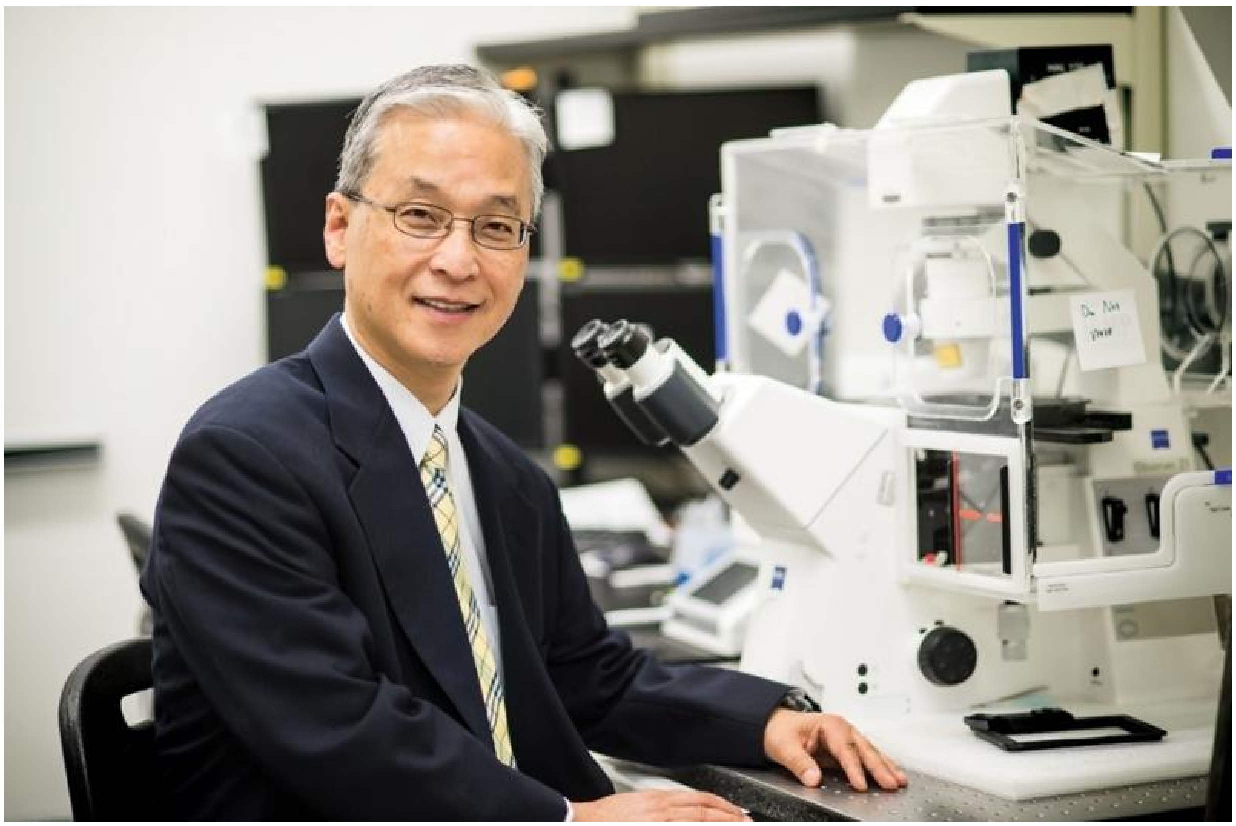

Dr. Michael Cho in his lab at the University of Texas at Arlington. With support from the Office of Naval Research, Cho is conducting research to better understand how explosive shock waves harm the brain and contribute to traumatic brain injury. Credit: Dr. Michael Cho

Today's warfighters are outfitted with body armor strong enough to withstand shrapnel from a bomb or other explosive device. One debilitating threat from a blast, however, is a force they can't see—the explosive shock wave itself.

"Shock waves travel faster than the speed of sound," said Dr. Timothy Bentley, a program manager in the Office of Naval Research's (ONR) Warfighter Performance Department. "Warfighters physically well protected from shrapnel aren't protected from shock waves. This wave of energy can cause subtle yet damaging effects on the brain."

To better understand how shock waves harm the brain and contribute to traumatic brain injury, ONR is supporting work by Dr. Michael Cho, chairman of the Bioengineering Department at the University of Texas at Arlington.

Cho's efforts center on the idea that explosive shock waves cause microcavitations, or tiny bubbles, to form and collapse in the brain. These energy-packed bubbles are so miniscule (less than a millimeter across) and appear, pop and disappear so quickly that they can't be detected by MRIs or other brain-imaging technology. Consequently, this kind of injury often goes untreated.

When brain microcavitations collapse, they can potentially damage surrounding cells and tissue, Cho said. He theorizes this collapse also compromises and causes leakage through the blood-brain barrier—a tightly packed network of blood vessels in the brain that allows healthy molecules to enter the brain from the bloodstream and prevents the entry of harmful ones.

Symptoms of this type of brain injury can include memory loss, headaches and even post-traumatic stress disorder.

"We know the symptoms are there," said Cho, "but they're not being addressed because we don't know the cause. If we can see that the blood-brain barrier is damaged, we can perhaps begin contemplating clinical strategies to treat the cause."

To accomplish this, Cho and his research team—working in partnership with Old Dominion University and Purdue University—have created tissue-based models mirroring the properties of tissue and fluids found in the brain and blood-brain barrier. They then use electrical charges to produce shock waves within the models, which are grown on petri dishes.

"Through this method, we can create microbubbles and compare their effects in real time," said Cho. "We can see the formation of tiny bubbles, watch the interaction with the blood-brain barrier model and determine what kind of damage or leakage might occur."

Future research also will involve developing computer algorithms and simulations to accurately predict what areas of the brain are most susceptible to microcavitation damage.

"Instead of scanning the whole brain for an injury, doctors could focus on specific areas most likely to be injured," said Cho. "They still won't be able to see the microcavitations, but they can look for localized biomarkers indicating their presence—proteins, chemical compounds and blood particles, for example."

In addition to offering a way to treat the thousands of warfighters who have returned from Iraq and Afghanistan with traumatic brain injuries, Bentley said Cho's research also can potentially help civilians suffering from trauma related to car accidents and contact sports.

Provided by Office of Naval Research