Engineers use 'shock tube' to find greater impacts of blast waves on brains

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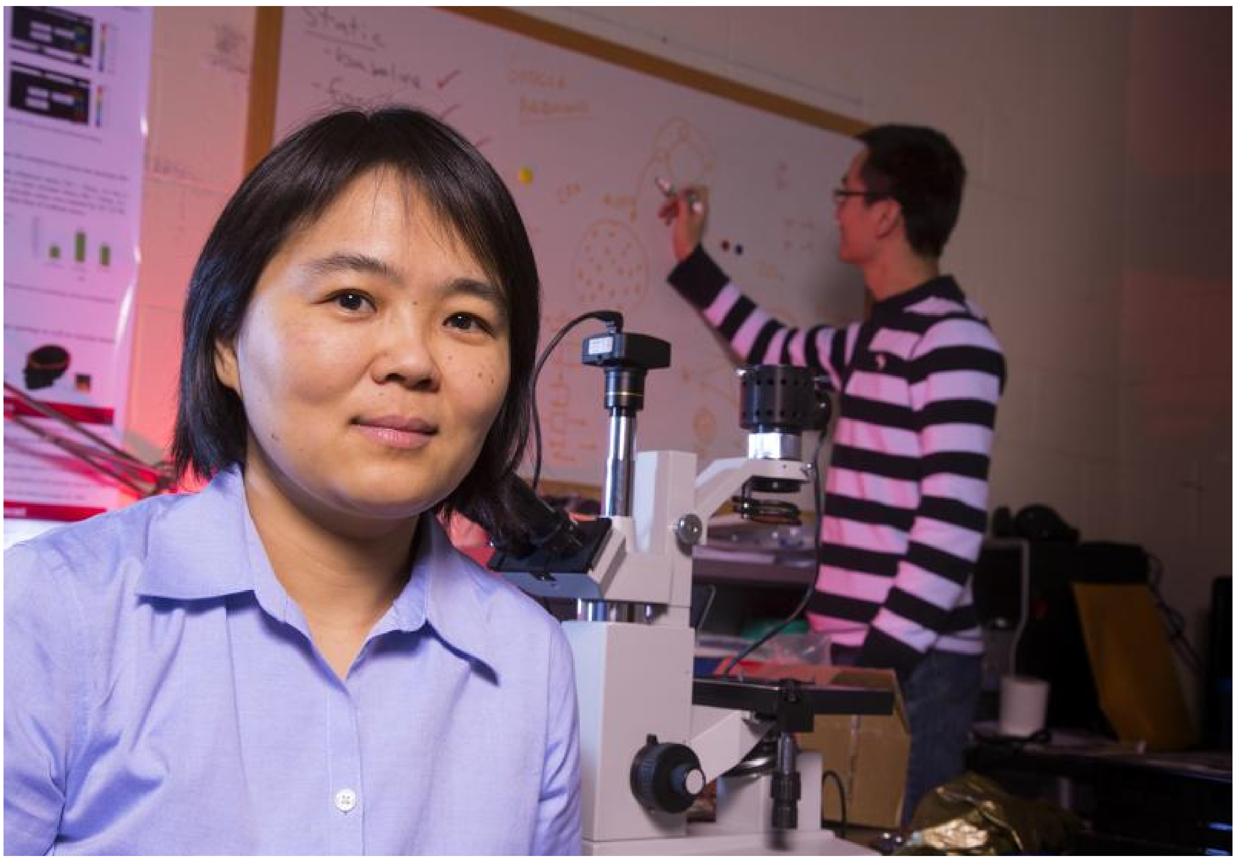

Linxia Gu, associate professor of mechanical and materials engineering, has authored new research showing that blast waves from roadside bombs may impact the brain with greater force than previously believed. Credit: Craig Chandler/University Communications

By accounting for a rush of blood to the head, University of Nebraska-Lincoln engineers have found that blast waves from concussive explosions may put far greater strain on the brain than previously thought.

The researchers have authored a study examining, for the first time, how blood vessel networks affect the potential incidence of traumatic brain injury from improvised explosive devices that blanket combat zones throughout the Middle East.

The team simulated the force of IEDs by using a "shock tube" to propel 900-mile-per-hour blasts of air at two models of the human head—one featuring blood vessels, the other without.

Sensors then recorded levels of strain, or how much these blasts deformed the brain in each model. They specifically measured principal strain—the maximum compression of a material at a specific point—and shear strain—the angular shift of an object's shape.

The model embedded with blood vessels suffered almost three times as much principal strain and more than six times as much shear strain in the brain stem. Its corpus callosum, which facilitates communication between the left and right hemispheres of the brain, experienced almost twice the principal strain and nearly 2.5 times the shear strain of its counterpart in the control model.

Similarly, the study showed that both types of strain rose in tandem with the density and diameter of blood vessels.

"If it turns out that these blood vessel networks really are having such a big impact, then maybe we've been underestimating the strains caused by blast waves," said lead author Linxia Gu, associate professor of mechanical and materials engineering.

Because blood vessels are much stiffer than brain tissue, Gu and her colleagues initially thought the vessels might reinforce the brain against blast waves in the same way that steel rebar strengthens concrete.

"This might be true for a lower-frequency blast loading, but under high-frequency loading, it's not," Gu said. "We think the interface between the vessel network and brain tissue contributes to the increased strains. It really seems to make a big difference."

The team's study was conducted through UNL's Trauma Mechanics Research Initiative, which houses a range of experiments aimed at better understanding and protecting against traumatic brain injury. The U.S. Department of Defense reports that traumatic brain injury has afflicted more than 320,000 veterans since 2000, calling it "one of the signature injuries of troops wounded in Afghanistan and Iraq."

Because so much about the issue remains in shadow, Gu said, every bit of new information could improve the design of helmets worn by military forces worldwide.

"If we understand how these blood vessel networks impact brain dynamics, maybe we can design (headgear) differently to optimize its protection," Gu said. "No helmet can protect equally against every type of force. Current helmets protect well against bullets and shrapnel, but they don't protect as well against blasts.

"To improve the design of a helmet, we need to know why this damage occurs. That's the ultimate goal."

The team's study appeared in the online journal *Computational and Mathematical Models in Medicine.*

Provided by University of Nebraska-Lincoln