



FORCE SCIENCE® NEWS

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In This Edition:

- I. What does it really take to kill someone with “compression asphyxia”?
- II. New study: Some notable patterns in officer UOF injuries
- III. In-box: Our readers write...
- IV. Study of ballistic vests & public perceptions now available

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What does it really take to kill someone with “compression asphyxia”?

I. What does it really take to kill someone with “compression asphyxia”?

Over the years, medical examiners and plaintiff’s attorneys have advanced a variety of speculations to explain the arrest-related deaths of suspects for which no medical cause is readily apparent.

This parade of horrors has included hog-tying, positional (prone) asphyxia, neck restraint, pepper-spraying, and cardiac disruption (electrocution) caused by conducted electrical weapons. And one by one, impartial scientific investigation has largely discredited these assertions.

Now a highly credentialed international research team offers fresh evidence that another alleged cause of ARD is a myth as well. That’s “compression asphyxia,” a fatal interference with breathing supposedly caused by officers kneeling, sitting, or lying on a resistant suspect’s upper body to establish and maintain control for handcuffing.



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While compression asphyxia is a commonly documented phenomenon in certain real-world circumstances, it's "crazy" to consider it a realistic possibility in the context of police street practices, according to the researchers' leader, Dr. Mark Kroll, an adjunct professor of biomedical engineering at the University of Minnesota and California Polytechnic University.

"Weight on the chest as a cause of arrest-related death?" Kroll says. "No way!"

Details of his group's findings are newly published in the journal *Medicine, Science and the Law*. That report is a dense thicket of technical language, but in an exclusive interview with *Force Science News*, Kroll recently translated its essence into laymen's terms.

EXPERT CREDENTIALS. With more than 370 patents to his name, Kroll is one of the most prolific inventors of medical devices in the world. He has won the highest international award in biomedical engineering, and in the law enforcement realm his scientific input was critical to the development of the TASER CEW.

He appears frequently as a consulting witness in police litigation, and it was in court that he first encountered the plaintiff claim that compression asphyxia could explain ARDs that seem otherwise baffling. In light of the truth behind other faddish but specious "causes" of ARD, he decided expert investigation was warranted.

He recruited four other PhDs or MDs from British and American universities to join him, including a forensic pathologist, a specialist in the mechanical strength of human bones, an authority on compression

deaths from "crowd crush," and a physician trained in emergency medicine who has studied ARD injuries.

THREATS KNOWN/UNKNOWN. First, the team established the known basics of death from compressive pressure on the human body.

"A fully loaded soft-drink vending machine weighing 1,100 pounds falling on you will kill you," Kroll says. "So can a car crushing you when a jack collapses, or the impact of a steering wheel slamming against your chest in a collision. But important experiments at the University of California-San Diego showed that a prone, hog-tied subject could withstand 225 pounds of weight on his back and still breathe just fine."

The team located official records from centuries back when lawbreakers and religious martyrs were subjected to "pressing" under weights piled on their chests for purposes of interrogation or execution. One highway robber bore 350 pounds for half an hour, while a woman was pressed to death in 15 minutes by an estimated minimum of 700 pounds.

"The pressing data shows that about 400 pounds on the chest was survivable because of diaphragmatic breathing, with communication still possible," Kroll says. "But over 626 pounds was fatal."

"A major mechanism of compression deaths" is the generation of what's known as "flail chest," he explains. This involves the fracturing of enough adjacent ribs in two or more places each to cause a segment of the rib cage to break free and move independent of the chest wall.

Such major damage “prevents effective breathing and can cause death even after the source of compression is removed,” Kroll says. “With five to seven ribs involved, you’re shot. Even breathing via your diaphragm (located below the chest) won’t help at that point.”

What he and his colleagues sought to objectively identify for the first time was the specific amount of traumatic force necessary to break enough ribs to cause flail chest. In effect, how much weight on the upper body is required to kill someone via compression asphyxia.

RESULTS. Obviously, testing live volunteers until they died was not an option. But based on the known strength of rib bones, the researchers were able to design a “biomechanical model” of the thorax that allowed for mathematical computations that approximate human experimentation.

From that, they predict a practical rule of thumb, Kroll reports: roughly 570 pounds (they calculated 573 plus or minus 57 pounds) of pressure on the front or back of the torso of a male subject in his 20s or 30s is required to break six ribs sufficiently to cause fatal flail chest.

“In other words,” Kroll says, “it would take two 285-pound cops standing and balancing on the back or chest of a suspect to produce compression asphyxia. And that’s simply not going to happen in the real world.”

Even if an officer were to drop forcefully on his knees onto a suspect, “it wouldn’t significantly change things,” Kroll says. “The weight of dynamic force from dropping needed to cause death is actually higher than the amount of necessary static weight piled

on a subject, because the rib cage has an impressive built-in ability to absorb the physical shock of sudden impact.”

Kroll acknowledges limitations to the study. The team’s calculations did not extend to female subjects, children, the elderly, or those with bone disease. He believes, though, that the findings are relevant for most subjects who resist arrest and might end up in a compression situation.

MYSTERY. “There are about 800 ARDs a year in the US, but some simply remain a mystery at this point,” Kroll says. “Sometimes when people fight the police the human body seems just to run out of gas for reasons that aren’t understood. These aren’t murders, yet the explanation is not clear and it’s not right to tie them to junk causations with no basis in science.

“I believe we need a new cause-of-death category: Arrest-Related Death Syndrome. We can name it first and understand it later as we learn more about it.”

[Note: More information on this and other related in-custody death topics are covered in the Force Science Certification Course. For more information e-mail: training@forcescience.org or call Scott Buhrmaster at: (312) 690-6213.]

Dr. Kroll can be reached at: mark@kroll.name. His team consisted of G. Keith Still, PhD, of Manchester University in England; Tom Neuman, MD, of the University of California-San Diego; Michael Graham, MD, of St. Louis University; and Lanny Griffin, PhD, of California Polytechnic University. Their study is titled: “Acute forces required for fatal compression

asphyxia: A biomechanical model and historical comparisons.”

II. New study: Some notable patterns in officer UOF injuries

A study of a year’s worth of force reports in one major US police department reveals some interesting patterns of officer injuries in non-shooting confrontations.

The review was led by Dr. Katelyn Jetelina, an epidemiologist with the University of Texas School of Public Health who specializes in violence prevention and injury. Her team included Dr. Steve Bishopp, a sergeant with Dallas PD.

The researchers analyzed 2,244 UOF reports, exclusive of shootings by or at officers, which by mandate must be completed every time a Dallas officer uses force “greater than compliant handcuffing.” The team sorted filings from 1,028 individual officers into four broad categories: verbal direction, including commands and “combat stance”; soft empty-hand control, including pressure points and threatened use of a CEW; hard empty-hand control, such as joint locks and “weapon display at person”; and intermediate weapon use, including “pepperball saturation and TASER deployment.”

Most officers (87%) who reported using force were male and non-Hispanic whites (58%). Forty per cent had been with DPD for fewer than five years and 13% recorded more than four UOF experiences during the year studied. Of suspects involved, nearly 80% were male and more than half were non-Hispanic blacks.

Out of 2,244 total reports, 10% “disclosed that an officer was injured,” the researchers found. Many hurts (38%) were just abrasions or swelling (20%), but 2% of officer injuries resulted in hospitalizations and some officers reported fractures and bites. Close to 2/3 of officers injured had multiple UOF encounters during the study period, with nearly 30% submitting four or more UOF reports. Up to 13 injuries were said to have occurred per incident.

Not surprisingly, Jetelina writes that “the odds of officer injury were significantly higher among active aggressive citizens.” Perhaps more notable were these other findings:

- The odds of officer injury were significantly lower “when [a suspect] displayed a weapon,” the team reports. Jetelina speculates that this “suggests that DPD officers are employing tactical [maneuvers] by increasing distance and time, if possible, upon encountering a suspect with a weapon [and thus preventing] premature and unnecessary physical force which leads to officer injuries.”
- Black officers were “significantly less likely to use verbal commands and hard empty-hand control than non-Hispanic white officers.”
- Officers with less than 10 years’ experience “were significantly more likely to use verbal commands and soft empty-hand control and less likely to use hard empty-hand control or intermediate weapons than officers with more than 10 years on the force.”
- Officers with five to 10 years on the job were “significantly more likely to sustain an

injury than officers with less than five years of tenure.”

- Proportionately, male officers were “significantly less likely to sustain an injury.”
- “[O]fficers were more likely to use verbal commands in interactions with non-Hispanic black citizens compared with non-Hispanic white citizens.”
- Of particular importance, the researchers emphasized, was their finding that “gradual escalation of use of force [was] shown to reduce police officer injury in high stress, high anxiety calls....” The study concludes: “Police departments should continue to train and educate police officers on the importance of gradual escalation of force when appropriate.

“This is especially evident among police officers with greater tenure who were less likely to gradually move through the force continuum.... [O]fficers, and likely citizens, directly benefit from gradual escalation in terms of injury incidence and this only highlights the importance and need of de-escalation techniques....”

The study appears in the journal *Injury Prevention*, under the title “Gradual escalation of use-of-force reduces police officer injury.” You can see a free abstract by clicking [here](#). The full report can be accessed for a fee at that site as well.

Our thanks to Lt. Glen Mills of the Burlington (MA) PD for alerting us to this study.

III. In-box: Our readers write...

Herewith, a representative sampling of reader responses to recent reports in *Force Science News*, lightly edited for brevity:

Regarding “1 columnist’s approach to getting civilians to walk in cops’ shoes,” FSN #334, 4/5/17:

“Skin in the game”... & a ready response
When I’ve taught use of force to citizen police academies, I’ve also suggested that attendees imagine their son or daughter (or other loved one for younger attendees) serving as a police officer and having to make force option decisions. It puts some skin in the game.

Sgt. John Converse
Rockville City (MD) PD

Regarding “Electronic control likely best option for excited delirium,” also FSN #333:

Core body temperature can be critically important
Excellent work on LE dealing with excited delirium syndrome!

One additional aspect: If a subject dies, the medical people on scene should be asked to take a body core temperature. Medical experts have told me that the results, if the case is indeed excited delirium, are often astonishingly high temperatures.

This is valuable info to communicate the fact that ExDS (something very powerful and very bad) was happening to the subject, and actions by police were not what caused the death.

Dave Grossman
US Army Lt. Col. (ret.)
Author, On Combat and On Killing

IV. Study of ballistic vests & public perceptions now available

In Force Science News #328 (1/10/17 - Click here to go to the FS News library) we reported on a new Force Science study on

how ballistic vests and their attachments impact public perceptions of police.

That study has now been published in the Journal of Police and Criminal Psychology and can be read in full free of charge by **CLICKING HERE**

https://link.springer.com/epdf/10.1007/s11896-017-9237-x?author_access_token=gk372ZY3CJrSf3Omp0XLSPe4RwlQNchNByi7wbcMAY6hk_kxlgEyJlptQQMlfT6BAFaPmSUkoKzatzBVQcJrDLM0b3ep1Jo39P9QqsopQWmliaz9GK_O6uIxFJyMuWBOPXQZ_fhxIS7UU9E8R24YHA==

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