assess the contributions of acutely raised intracranial pressure and inertial forces. The importance of rigour in an area of pathology so closely related to issues of criminal law and justice need hardly be elaborated.

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Effects of stun guns and tasers

Plans by the Metropolitan police in the UK to introduce the use of tasers to subdue violent or threatening people has raised queries about the safety of these weapons and the kind of research that these weapons have undergone. They have been used by the police in the USA and elsewhere since the mid-1970s. Like any other tool, tasers and related devices have been misused, and they have even been used for punishment and torture. Research published on tasers consists largely of examination of people who have been fired at.

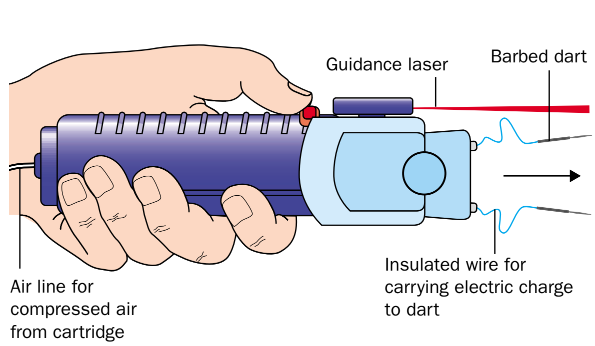
Tasers and stun guns are high-voltage, low-current stimulators (figure) that can cause involuntary muscle contractions and sensory responses, such as various degrees of pain and the feeling of exhaustion. The electrodes are fixed in stun guns but are shot out as darts from tasers. These devices produce electrical stimuli in the form of short-duration (small fraction of a millisecond), repetitive pulses (5–30 pulses/s), each of 50 000 volts. Since currents can be conducted by electrical arcs, effective contact with the body of the person targeted at can be made even if the darts (electrodes) that carry the electrical charge land on thick clothing or if one lands on the ground and the other on the person.

The effects of tasers vary greatly, depending on electrical characteristics of the particular device, placement of darts, distance between the darts (a function of the distance from which the gun is fired), and the condition of the person being fired at. In stun guns the electrodes are usually about 5 cm apart, but darts from tasers diverge when fired, and the wider the distance between them when they land on the target, the greater the effect.[1] For example, electrodes 5 cm apart applied directly over the vastus lateralis muscle does not inhibit voluntary function of the muscle during stimulation or afterwards. After about 5 s of application of the stun gun, individuals who have been trying to resist will stop doing so, presumably because of pain or fatigue. By contrast, taser darts placed 10 inches apart (the distance reached if fired from about 6 feet) over the vastus lateralis in the same person will lock the leg in the flexed position, typically leading him or her to surrender quickly.[1]

The effects of stun guns have been reported to increase with duration of application. With electrodes 5 cm apart, applications of up to 0·5 s will cause the victim to be startled and repelled. 1–2 s of discharge of current will cause the victim to fall. Falls commonly occur in a slow semi-controlled fashion. The degree of sensation evoked by these devices can result in a response that far outlasts the duration of the current, so discharges of 3–5 s may leave the victim immobilised, dazed, and weak for 5–15 min.[2] In most people a stun gun applied for 4–5 s under the rib cage will bring them to their knees and weaken them.[1]

Because of the difference in excitability between nerves and cardiac muscle, and because the heart is distant from the skin, myocardial stimulation is extremely unlikely in normal use of these devices (ie, with darts striking the skin). Studies of the cardiac

How a taser works



The taser can resemble a torchlight or handgun. Some models have a laser to help in aiming the dart at the target. Compressed air cartridge worn on belt; not needed in models propelled by gun powder.
Darts diverge as discharged. They remain attached to the taser via trailing wires.

effects in Yorkshire pigs have involved application of stun-gun electrodes directly to the pericardium of the exposed heart.[3] Ventricular fibrillation was induced with only the highest-power stun gun tested. Other stun guns tested in this way induced non-lethal dysrhythmias. When the highest-power stun gun was applied to saline-moistened skin of the chest of a pig that had an implanted pacemaker, ventricular fibrillation occurred.[3] Further research on what other cardiac effects tasers and related devices would have in people with pacemakers is needed.

Tasers may cause complications if the eye or a blood vessel is penetrated, or if there is secondary trauma from a fall. Other injuries reported in anecdotal form include contusions, abrasions, lacerations, mild rhabdomyolysis, and testicular torsion.[4] There is also a theoretical possibility of tissue injury due to electroporation (cell-membrane disruption due to high voltage gradients across tissues). Involuntary urination and defaecation has been mentioned as a possible side-effect of stun belts (devices with a remotely controlled stun gun used in prisons and court rooms).[5] There has also been a case-report of miscarriage in a woman who received a taser injury at 8–10 weeks of pregnancy when she was in custody for drug abuse.[6]

In one study 218 patients seen at an emergency department after being shot by a police taser for violent or criminal behaviour were compared with 22 patients who had been shot by police with 0·38 calibre guns.[4] The two groups were similar in age, sex, and misuse of drugs. None of the taser victims had serious long-term effects, whereas 50% of those with bullet wounds did.

In this same study, three (1·4%) of those fired at with a taser died, compared with 11 (50%) of those fired at with bullets. All three patients who died after being fired at with a taser had high plasma concentrations of phencyclidine. One patient was also on digoxin and had a history of sick-sinus syndrome and mitral-valve prolapse. This patient went into respiratory arrest followed by cardiac arrest 25 min after being shot. The other two patients had no history of cardiac disease and went into cardiac arrest 5 and 15 min after being fired at. Immediate induction of ventricular dysrhythmias by electric current thus does not seem to be the mechanism of death in these cases.

In another study, in which 16 deaths associated with use of the taser were examined,[7,8] no adequate information about the time between the injury and respiratory or cardiac arrest was provided. However, eight of these 16 patients who died had taken phencyclidine, one had taken amphetamine, and six had taken cocaine. The patients who died but who did not have evidence of having taken phencyclidine or cocaine had mechanical trauma (such as gunshot wounds). In only one case (who had had heart disease) was the taser thought to have contributed to the death, although this conclusion has been challenged.[8]

Apart from, but probably related to, drug addiction, another feature that taser-injured people generally have in common is severe agitation plus physical aggression. Some of these people may have a metabolic acidosis. Acidosis may increase ventricular dysrhythmias, especially in the presence of phencyclidine and cocaine. The taser itself may affect acid-base balance by briefly increasing skeletal muscle activity and decreasing respiration. However, the cardiac arrests in the patients reported by Ordog and colleagues[4] occurred 5–25 min after the tasers were fired. By this time taser-induced muscle contractions would no longer be present, and one would expect the individuals to be relaxing and able to breathe in a way that would compensate for a metabolic acidosis. Such may not be the case if the individuals remained agitated or were prevented from breathing freely. It is not known how the patients in the reported cases were acting at time of arrest.

The implication of these findings is that when people who have been fired at with a taser seek medical attention, their acid-base status should be checked if they have been agitated and seem unwell (a point that applies also to people who have not been fired at with a taser). If necessary, they should then be given respiratory support and their acid-base balance should be restored. Such treatment has been helpful in restoring cardiac rhythm and function to normal in cocaine users with metabolic acidosis.[9] In dogs given phencyclidine respiratory support increased the mean lethal dose of the drugs.[10]

It is clear that, properly used as a method of restraining violent people, tasers are less likely than guns to cause injury and death of the target (and of the police officer). They are also generally more effective than other methods of restraint. The deaths that have followed taser use have occurred in people who were out of control and who had taken potentially fatal drugs. In such cases it is quite possible that the deaths would have occurred whether or not the taser was used.

Nevertheless, apart from issues related to cardiac pacemakers mentioned above, there are others that still need to be researched. Injury thresholds need to be studied, as do the effects of tasers on the nerves. Methods of stratifying people at risk of respiratory or cardiac arrest should also be examined, as well as the degree of blood-gas correction needed to minimise this risk. Finally, the mechanisms of injury by tasers should be compared with those of physical and chemical methods of restraint, so that the safest method can be used for any specific situation.

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