



Research Paper

Eye injuries from electrical weapon probes: Incidents, prevalence, and legal implications

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ABSTRACT

Purpose: While generally reducing morbidity and mortality, electrical weapons have risks associated with their usage, including burn injuries and trauma associated with uncontrolled fall impacts. However, the prevalence of significant eye injury has not been investigated.

Methods: We searched for incidents of penetrating eye injury from TASER[®] conducted electrical weapon (CEW) probes via open source media, litigation filings, and a survey of CEW law-enforcement master instructors.

Results: We report 20 previously-unpublished cases of penetrating eye injury from electrical weapon probes in law-enforcement field uses. Together with the 8 previously published cases, there are a total of 28 cases out of 3.44 million field uses, giving a demonstrated CEW field-use risk of penetrating eye injury of approximately 1:123 000. Confidence limits [85 000, 178 000] by Wilson score interval. There have been 18 cases of total unilateral blindness or enucleation. We also present legal decisions on this topic.

Conclusions: The use of electrical weapons presents a rare but real risk of total or partial unilateral blindness from electrical weapon probes. Catastrophic eye injuries appear to be the dominant non-fatal complication of electronic control.

1. Introduction

Electronic control with a conducted electrical weapon (CEW) has broad acceptance with law-enforcement as the preferred less-lethal force option due to its proven injury reduction compared to other control tools. Large prospective studies find subject injury rate reductions of about 65%.¹ This is consistent with a 2/3 reduction in fatal police shootings where CEW usage is not overly restricted.² A prospective study found that 5.4% of CEW uses clearly prevented the use of lethal force by police.³ Of the 310 000 annual CEW field uses, 1 in 3500 is involved in a non-firearm arrest-related death (ARD) vs. the baseline ARD rate of 1:1000.⁴ CEWs are also reported as the most effective force option with up to ~75% of uses being effective, from mere presentation, without the need for CEW deployment or discharge.⁵

The short-duration (60–110 μ s) electrical pulses applied by CEWs are engineered to stimulate Type A- α motor neurons to control skeletal muscles but with minimal risk of stimulating cardiac myocytes.

Effective application of a CEW causes a loss of regional muscle control and can result in an uncontrolled fall to the ground to end a potentially violent confrontation.^{6,7}

Despite documented decreases in injuries to suspects, the use of electrical weapons have rare, but significant, risks, including fatalities from falls and burns.^{8–10} CEWs launch probes with darts, and, hence, there is a risk of significant eye injury. See Fig. 1. The goal of this paper is to present the risks of such injury and discuss the present warnings and legal decisions.

A CEW has both LASER and fixed aiming sights. The X26 CEW series has a single LASER that approximately aligns with the top probe. The lower probe is launched at a separation angle of 8° below the LASER line as shown in Fig. 2. To obtain significant motor-nerve mediated neuromuscular incapacitation there must be a probe separation of at least 30 cm (12 in) on the front of the body.⁶ This required probe spread increases the risk of facial impact and eye injury due to dart penetration and impact from the main probe body (see Fig. 3).

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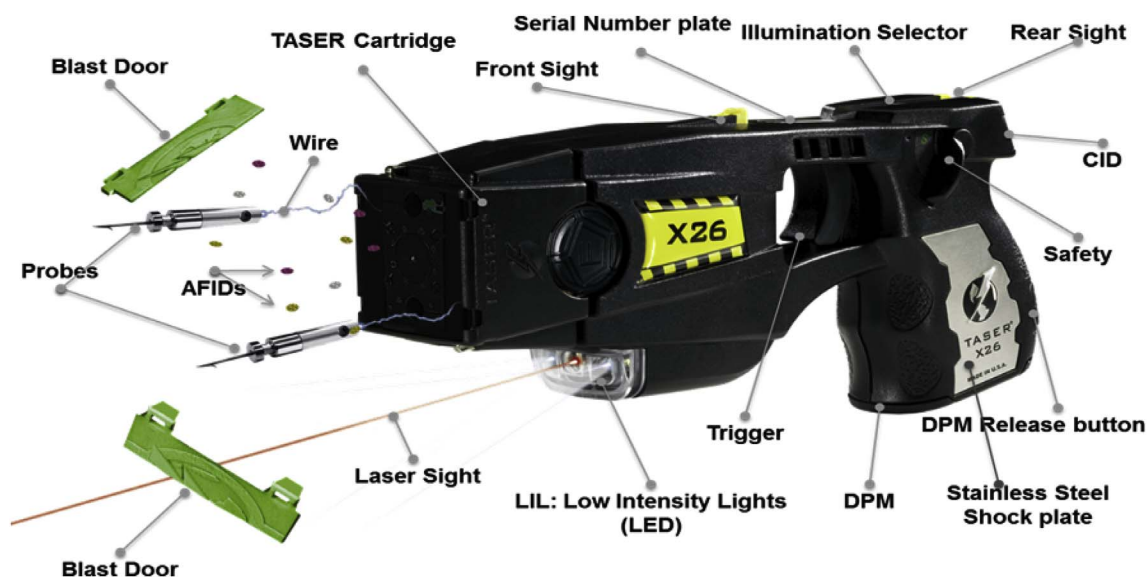


Fig. 1. X26(E) CEW during probe deployment.

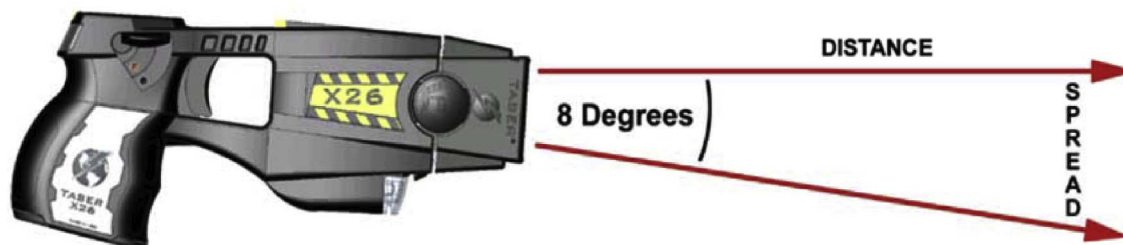


Fig. 2. The lower probe is launched at an angle of 8° below the LASER line.



Fig. 3. Single-shot probe as used in X26 models. Dart portion is 13 mm long; other version has 9 mm dart.

2. Methods

We searched open source media (Google News) and legal databases (Westlaw) for cases of ocular probe penetrations up to 1 Aug 2017. In addition, a survey was sent to 507 Axon (fka TASER) Inc. Master Instructors in the manufacturer's database, and 128 completed the survey. Master Instructors are responsible for the training of the 20 500 certified basic instructors at the various agencies. Larger agencies such as London Metropolitan and Los Angeles Police Departments have their own Master Instructors but smaller agencies share regional ones. These responding instructors covered 52% of CEW-adopting agencies, and we believe that these responders had knowledge of most of the dramatic incidents in those agencies. The results were then cross-referenced to

the 12 published injury case reports (comprising 8 globe penetrations and 4 peri-ocular landings of probes) to eliminate duplications (of which there was only 1).

We used the manufacturer's estimate of worldwide field uses for the denominator. The statistical model has been published and the number is updated on their website.¹¹ The Wilson score interval was used for estimating the binomial proportion confidence interval.

3. Results

We found 20 cases of penetrating eye injury that had not been previously reported in the indexed medical literature. There were 15 from open source media, 3 from legal databases, and 2 from the instructor survey. See Table 1 for the listing. The searches also developed 4 injury cases that did not involve field-use but were due to law enforcement officer and civilian accidents.

Including the 8 previously published cases, there were 28 such injuries out of 3.44 million field uses, giving a demonstrated risk of approximately 1:123 000. Confidence limits [85 000, 178 000] by Wilson score interval. The mean age (for the new cases) was 30.3 ± 11.7 years; combined with the published cases the mean age was 31.1 ± 12.1 years. Both age distributions are consistent with the typical CEW-force recipient according to Strote (32.0 ± 10.7).¹²

In combination with the 8 published case reports we report 12 enucleations and 6 cases of complete blindness and thus the majority (18/28) resulted in a loss of vision. In total there have been 7 cases of partial blindness, and 2 cases of normal vision after successful surgical repair. (There was a case lost to follow-up after a surgical repair attempt.) With 18 identified cases, there is a risk of .64, CI [0.47–0.82] for unilateral blindness or enucleation from a penetrating eye injury, primarily from globe rupture. See Table 2 for summary.

Table 1
Penetrating globe injury field use cases.

Year	Age	Sex	State	Source	Code	Case# in Appendix or Citation [superscript]
2004	50	M	AU	CR	N	28
2005	21	M	CA	Media	P	1
2005	21	M	OR	CR	P	29
2007	27	M	TX	Survey	B	2
2007	18	M	CA	Media	P	3
2008	24	M	CA	Legal	B	4
2008	25	M	Ont	CR	N	30
2008	46	M	KR	CR	E	31
2009	43	M	TN	Legal	E	5
2009	26	M	MO	CR	E	32
2011	52	M	PA	Media	E	6
2011	19	M	TX	Media	B	7
2011	34	M	NM	Survey	P	8
2011	27	M	FL	Media	P	9
2012	47	F	TX	CR	?	33
2013	24	M	OH	Media	P	10
2013	22	M	FL	Media	B	11
2014	36	F	QU	Media	E	12
2014	55	M	SctI	Media	E	13
2014	31	M	CA	Media	E	14
2014	21	M	WA	Media	B	15
2014	24	M	NY	CR	E	34
2014	36	M	TX	CR	E	35
2015	22	F	MO	Media	P	16
2015	26	M	AL	Legal	E	17
2015	20	M	QU	Media	B	18
2015	53	M	FL	Media	E	19
2017	31	M	NY	Media	E	20

CR = Case Report. Ont = Ontario, Canada. SctI = Scotland. QU = Queensland, Australia. N = normal vision, P = partial blindness (pinhole or blurred vision), B = blindness, E = enucleation.

Table 2
Summary of outcomes of penetrating injury.

	Enucleation	Blindness	Partial Blindness	Normal Vision	Unknown	Total
New Cases	8	6	6	0	0	20
Published	4	0	1	2	1	8
case re-ports ^{28–35}						
Total	12	6	7	2	1	28

Our survey of master instructors found only 2 additional cases that were not found in media and legal databases or that were previously published. We assume that master instructors would be aware of all dramatic incidents in the agencies that they are responsible for. Based on the survey response rate of 25% (128/507) covering 52% of agencies, we speculate that there may be another 2–6 unreported cases — probably not involving blindness or enucleation.

A surprising finding was the 4 accidental deployments resulting in globe penetrations of officers or a family member. These 4 incidents are not included in the risk statistics as there is no meaningful denominator; they are summarized at the end of the [Appendix](#).

4. Discussion

We believe that this paper represents the first systematic analysis of the risk of penetrating eye injury from electrical weapon probes. We found 20 previously-unpublished cases of penetrating eye injury due to CEW probes during official usage. In combination with the 8 published case reports we report 12 enucleations and 6 cases of complete blindness and thus the majority (18/28) resulted in a loss of vision.

Prospective injury studies have not reported eye injuries from CEW

probes.^{13,14} Given the low rate of such injuries and the total cases analyzed (1705) this is to be expected.

Globe penetration and rupture may not be the only mechanism by which a CEW probe could damage the eye. Electroporation from the voltage spikes of CEWs has been suggested as a possible means of tissue injury. This has been well studied and electroporation effects appear to be limited to < 1 mm from the probes where it helps sterilize the probes.^{15,16} We suspect that there may have been some confusion caused by the misunderstanding that CEWs deliver 50 000 V to the body vs the actual 600 V seen with typical physiological loads.¹⁷ Case-report authors could then draw on the lighting and powerline injury literature to expect remote electrical damage to the eye.¹⁸

We remain open-minded but somewhat skeptical of the occasional hypothesis of non-penetrating electrical eye injuries from electrical weapons such as subretinal hemorrhage or cataracts.^{19,20} This is for two reasons: (1) The electrical output (< 2 W) appears too low to cause such damage, and (2) cases such as that reported by Jey et al., where there was a peri-ocular probe yet no reduction in vision.²¹

We have recently reported on 4 non-fatal major burn injuries from CEW-exposure with gasoline fumes present.¹⁰ With the present 18 case of unilateral blindness and enucleation, it appears that these penetrating eye injuries may be the dominant major crippling injury risk demonstrated with electronic control. While head-injuries from falls are reported, there have been no published estimates of *non-fatal* chronic brain injury so that prevalence is unknown.^{8,22}

4.1. Warnings and legal issues

No court decisions on CEW-induced eye injury were found in the legal databases for the United Kingdom, Australia, and Canada. Hence, the legal discussion below focuses on US rulings.

The major manufacturer, Axon, warns that CEWs are not precision-aimed weapons:

Warning: Probes may deviate. CEWs are not precision-aimed weapons. Probe discharge, flight trajectory, and impact location can be affected by numerous factors, including cartridge or probe accuracy; failure of cartridge to properly deploy; strong air movements; user and subject movements; ...

In *Forrest v Prine*, in a jail cell setting, a CEW was aimed at the subject's upper back, but a probe ended up striking him in the face due to his sudden (head spinning) movement “like a duck.”²³ The Court concluded that a police officer is not expected to always precisely hit his target when the target is moving.

Projectile eye-injury cause-and-effect is common knowledge and should not require a specific warning. However, the major manufacturer, Axon, warns:

Warning: Eye Injury Hazard. A TASER probe, electrode, or electrical discharge that contacts or comes close to an eye can result in serious injury, including permanent vision loss. DO NOT intentionally aim a CEW, including the LASER, at the eye of a person or animal without justification.

In September 2009, the company lowered the preferred point of aim from the torso center to lower-center in part to lessen the risk of probe placement into undesirable areas, including the head and face. See [Fig. 4](#). The officer's objective in launching the projectile, the targeting point, and the totality of circumstances are important components in determining whether a projectile affecting the eye is legally justifiable or not.

These issues are not confined to electrical weapons. For example, the JPX pepper-spray gun pyrotechnically launches an 11 cc charge of OC (Oleoresin Capsicum) at a high velocity of ~170 mps (570 fps) for an effective range of 7 m (23 ft). The muzzle energy is 160 J compared to the 2.6 J of a typical CEW probe. The high energy drives the OC deeper into the skin than an aerosol propellant would. In 2012, a

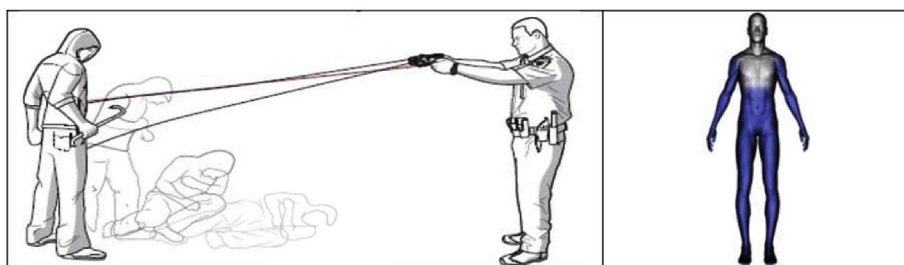


Fig. 4. Preferred targeting was lowered to lower center mass in September 2009.

California officer effected a traffic stop of a female driver and ended up shooting her from a distance of < 30 cm (1 ft), in violation of the JPX warned 1.5 m (5 ft) minimum safety distance.²⁴ The parties disputed whether she was hit in the face or in the side of the head but her right eye was “ripped apart” and the left eye was severely damaged leading to bilateral blindness. The Police Department determined that the officer’s use of the JPX was an unreasonable and excessive use of force. As a result, he was terminated from employment and indicted for felony assault by a public officer, and assault with a deadly weapon among other things.

A fundamental issue for excessive force is the intent of the officer. There are several categories of intent, including:

1. **Intentional: Intentional CEW deployment to the head, dart striking the eye.** In *Stephens v. City of Tarrant* (our case #17), an officer had been chasing the fleeing criminal subject, reported to be armed with a firearm.²⁵ Stephens alleges that he fell to the ground prone, unarmed and unresisting, and the officer caught up to him and shot him in the face with his CEW so that a probe punctured the right eyeball. The pursuing officer states that the fleeing Stephens stopped and turned around in an aggressive stance and the officer aimed for lower center mass. Under the officer’s version, the use of the CEW was objectively reasonable under the totality of the circumstances as reasonably perceived by the officer. Under plaintiff’s version the officer’s CEW deployment would not be objectively reasonable.
2. **Negligent: Improper handling of CEW resulting in dart in eye.** In *Khansari v. City of Houston* (our case #7), plaintiffs alleged that the officers did not aim their CEWs at subject’s head or eye but because of improper handling, they caused a probe to deploy in the direction of subject’s eye, which was negligent.²⁶ Simple negligence does not reach the level of a U.S. Constitutional rights deprivation. However, in some states negligence by an officer can be a legal cause of action.
3. **Indiscriminate: Undifferentiated targets.** In *Nelson v. City of Davis* an officer, shooting pepperballs into a crowd, struck a college student in the eye with a pepperball without any warning, causing him multiple surgeries, and permanent eye injuries.²⁷ According to the student, he did not disobey police orders (which were not even given until after the projectile was shot), but was merely part of a large party that police were trying to break up. Indiscriminate intentional launching of projectiles into a crowd (without individual threat justification) will foreseeably rise to the level of a Constitutional violation.

An intentional CEW probe in the eye is a serious event requiring significant legal justification. Officers are prohibited from intentionally targeting a subject’s head, including face and eyes, unless the subject is reasonably perceived as an immediate threat of death or serious bodily harm to officers or others, not just himself (e.g. suicidal). In most US jurisdictions, officers have enhanced thresholds for using force against a suicidal subject who is not an immediate significant threat to officers or others. Where the sole justification — for the apprehension of a subject

— is preventing self-harm, the government has little interest in using force.

5. Limitations

A prospective experimental study would generate superior data compared to our retrospective data. However, a relevant experiment would have difficulty obtaining ethical approvals.

There is no national database that records data in such incidents, so secondary sources are the only sources of information available to identify the relevant cases. Also, primary sources of data, such as police reports are not available in all states and countries, depending on their public information laws. Police reports, and news accounts are also subject to bias. US hospital records are protected by the US Federal HIPAA privacy law. Most likely due to the sensationalistic nature and litigation potential of such incidents, there does not appear to be significant underreporting of penetrating eye injury from CEW probes.

Due to the extensive media coverage of any arrest-related-catastrophic injury, we are confident that we have missed few enucleation cases. For the less-severe cases, our confidence decreases with the decreasing severity. Based on the few new cases found by the Master Instructor survey, we estimate that there are another 2–6 partial blindness cases that we failed to find.

We also note that the sampling frame is less rigorous than we would prefer. However, there is no practical alternative. We invested significant time searching open records sources to identify cases for this study. We focused our examination on those cases when the electrical weapon use resulted in an eye injury. Those instances are very rare, but they are critically important to understanding the risks of using such weapons.

6. Conclusions

We report 20 previously-unpublished cases of penetrating eye injury from electrical weapon probes in law-enforcement field uses. With the 8 previously published cases there have been a total of 28 such cases out of 3.44 million field uses, giving a demonstrated CEW field-use risk of penetrating eye injury of 1:123 000 uses. There have been 18 identified cases of unilateral blindness or enucleation, giving a risk of .64, CI [0.47–0.82] from a penetrating eye injury, primarily from globe rupture.

Disclosures

MWK is a member of the corporate and scientific advisory boards of Axon (fka TASER) who partially funded this work. MAB is litigation counsel for Axon and Member/Manager of LAAW, LLC. HEW is a retired police chief and received a speaking honorarium from Axon. MWK, MAB, and HEW have done expert witnessing in use-of-force cases. MBR, EAK, NKS, and RS report no conflicts.

Appendix. Summaries of previously unpublished cases

CEW field deployments (unintentional Probe-Eye contacts)

1. A 21-year-old deaf and mentally disabled man was involved in a disturbance with his girlfriend. When officers arrived, he began to walk away and then turned toward police with a hand in his jacket pocket. He failed to comply with officers' orders to stop and show his hands. An officer deployed his CEW, and a probe struck the man in the left eye. He suffered permanent blindness.
2. A 27-year-old-male subject ducked to tackle an officer while the officer deployed his CEW. A probe hit the subject in the eye. The suspect then pulled the probe from his eye and ran away. The subject was re-arrested weeks later by the same officer and reported only mildly blurred vision in the injured eye.
3. An 18-year-old suicidal male called police. The man had departed his residence before officers arrived, but they found him nearby driving his vehicle away. The officers eventually cornered his vehicle, but he resisted their efforts to remove him. During the struggle, an officer deployed a CEW striking the man in the eye. He suffered permanent partial blindness.
4. A severely intoxicated (0.31% BAC) 24-year-old man was being sought for domestic violence. He walked briskly toward a police officer and refused commands to stop. The officer recalled that the top probe was aimed at the center of the chest, but instead it landed in the right eye. The subject denied the presence of a probe in his eye even after being informed of this. Emergent non-consented surgery for globe rupture revealed that the probe was firmly implanted through the temporal sclera and corneal limbus and was attached to the posterior sclera choroid and retina. After surgery and retinal healing, right-eye vision was 20/200.
5. A 43-year-old suicidal male suffering from depression and other mental disorders and holding a knife, was on the front porch of his residence. An officer deployed CEW probes contacting the subject's chest and left eye. After 3 unsuccessful surgeries, the damaged eye was removed.
6. A 52-year-old mentally-ill male was creating a disturbance. When officers arrived, he was combative so an officer deployed his CEW probes striking the man in his right eye. The eye was later removed.
7. Parents of a suicidal 19-year-old male called police for assistance. During a confrontation in their front yard, an officer deployed a CEW, with a probe striking the subject in the right eye. The man pulled the probe from his eye and went back into the house. He was later subdued, but lost vision in the eye.
8. An officer deployed his CEW as a 34-year-old male charged him. The subject ducked and was struck in the left eye. Physicians removed the probe and he suffered partial blindness.
9. Police responded to a fight that had spilled out of a bar. An officer on horseback said he tried to have his horse shoulder the fighters apart and told them to stop, but they ignored him. The officer then aimed his CEW at the primary aggressor's right lower shoulder blade and yelled, "Taser! Taser! Taser!" As the officer deployed the CEW, the 27-year-old man turned toward him and ducked down. He ended up being hit by the prongs in the shoulder and right lower eye lid. The retina of his right eye was torn and had to be surgically lasered together leaving him with partial blindness.
10. A 24-year-old male was asleep in his pickup truck when officers attempted to awaken him. When they tried to remove him from the truck, he resisted. A deputy deployed his CEW, striking the man in his right eye. The man later filed a lawsuit claiming to have severely limited vision in that eye.
11. A 22-year-old male was involved in a disturbance in front of a bar. When an officer approached, the man was holding a handgun. When the subject refused to drop the gun, the officer deployed his CEW, striking the man in the right eye resulting in permanent blindness.
12. An intoxicated 36-year-old female became upset and created a disturbance following a visit from her social worker. When police arrived at her home, she threatened them with a broken table leg with protruding nails. An officer deployed his CEW and a probe struck the woman in her left eye, leading to removal of the eye.
13. A 55-year-old suicidal male armed with a large knife locked himself in his bathroom. When officers arrived, the man refused to drop his knife. Officers deployed a pyrotechnic distraction device and then a CEW. A probe penetrated the man's eyeglasses and lodged in his left eye. The injury required removal of the eye.
14. A 31-year-old male and 2 other people were sitting in a vehicle when officers approached. The officers, smelling burning marijuana, spoke with the occupants and ordered them to get out. A struggle ensued with the man, and officers deployed a CEW with a probe striking the man in his left eye leading to its eventual removal.
15. An officer ordered a 21-year-old driver to return to his vehicle, but he ran towards his house. The officer grabbed the driver by his sweatshirt, and a struggle ensued. The officer deployed his CEW and a probe struck the man in his left eye, resulting in loss of sight in that eye.
16. A 22-year-old schizophrenic female threw a bottle at another woman's car who then started fighting the female with help from a 3rd woman. An officer arrived and stopped the assault, but the female then turned on her attackers. When she refused the officer's orders to stop, he deployed his CEW. A probe struck her in the left eye, apparently due to her erratic movements. The injury required several surgeries to repair, and she has partial blindness.
17. A 26-year-old male received a probe in the right eye during an arrest and it punctured the eye. It was removed and the man is serving a 20-year prison sentence, awaiting an ocular prosthesis.
18. Police were called to a residence after reports of a mentally ill 20-year-old male threatening others with knives. The man charged at police with a knife. An officer deployed his CEW, which caused the man to drop the knife. However, when he picked up a second knife, the officer deployed a second CEW cartridge, this time striking the man in the left eye. The eye was salvaged, but the man lost his vision in that eye.
19. A 53-year-old suspect in the disappearance of a woman and their 9-year-old daughter lost his right eye after police attempted electronic control as he stabbed himself in the neck with a box cutter while sitting in his truck in a parking lot. The man was hit in the eye after he raised the box cutter, which deflected the CEW probe. The right eye had to be removed.
20. Police responded to a NY City call of a wife-beating. When the officers arrived, the assault was still going on, with the wife holding the couple's 2-year-old daughter. At that point, the suspect punched a sergeant in the face, cutting his chin. The sergeant then deployed his CEW at the suspect, but it did not work. Then another officer deployed his CEW, with a dart striking the man in the chest and the other in his right eye. The suspect was charged with assault, assaulting a police officer, resisting arrest and acting in a manner injurious to a child. His eye was removed.

Law enforcement training unintentional CEW deployment incidents

(not included in statistical analysis)

1. A 27-year-old officer accidentally discharged a probe into her own eye with permanent reduced vision.
2. During training, an officer pulled his CEW trigger to verify battery operation. He then inserted a cartridge before the 5-s cycle ended, thus accidentally deploying the probes. A probe struck his left eye. Surgery was planned to remove the probe from the eye.

Non-training unintentional CEW deployments

(not included in statistical analysis)

1. A police officer was showing his 14-year-old stepdaughter how to spark-test a CEW when it deployed the probes and a probe struck her in the eye. The girl had a blind spot in her right eye and is expected to have cataracts requiring surgical correction. The officer pleaded guilty to 2 misdemeanor counts — knowing and reckless child abuse resulting in bodily injury and prohibited use of a weapon.
2. A 2-year old girl was struck in the eye by a CEW probe deployed by siblings. The probe was removed by a trauma surgeon. Despite rapid intervention, the child now has a shrunken nonfunctioning eye.

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