Part 9

Medical Risks

PART 9: MEDICAL RISKS

A. INTRODUCTION

Since 2003, eight people have died in British Columbia after a conducted energy weapon was deployed against them. Six of these died in municipalities policed by the RCMP, while two died in the city of Vancouver. In Canada as a whole, 25 have died, nine of whom have died since Robert Dziekanski died at the Vancouver International Airport on October 14, 2007. All 25 died either at the scene or soon thereafter, in police custody or while hospitalized.

According to Amnesty International, more than 300 people have died in similar circumstances in the United States.[153]

The manufacturer has steadfastly maintained that its weapons are not responsible for these deaths. For example, when a Calgary man died in early November 2008 after a conducted energy weapon was deployed against him, the manufacturer's vice-president for communications was quoted as saying, "Not one coroner in Canada has ruled any death was caused by a Taser device or even contributory to date."[154]

And yet, well over 300 people have died in North America in what has become known as "death proximate to TASER use." A scenario that repeats itself with troubling regularity finds a highly agitated and combative man who is unresponsive to an officer's commands subjected to one or more cycles of a conducted energy weapon. The man falls to the ground and, while incapacitated, officers restrain and handcuff him. Shortly thereafter the man lapses into unconsciousness, cannot be resuscitated, and is pronounced dead at the scene or upon arrival at the hospital.

When it is suggested that the conducted energy weapon caused the death, the manufacturer and local police force will frequently observe, correctly, that no physical evidence was found during the autopsy suggesting that the weapon's

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153 Oral submission by Hilary Homes during the Commission's public forums. Transcript, May 15, 2008, p. 31.

154 As quoted in "Taser reaction 'near insanity'; Company vice-president says concerns over stun-gun safety overblown." *The Calgary Sun*, Wednesday, November 5, 2008, byline by Nadia Moharib, Sun Media.

electrical current triggered a heart attack or other cardiac or respiratory malfunction causing or contributing to the death. Rather, it may be suggested, death may be attributable to a phenomenon called “excited delirium,” that could have been brought on by a pre-existing mental illness and/or drug usage.

In such cases, the official cause of death is often ambiguous, police forces continue to deploy conducted energy weapons, and people keep dying. The debate rages on about whether conducted energy weapons are safe, or whether they should be banned or at least have a moratorium placed on their use until their safety can be established.

Because they transmit an electrical current into the body of the subject, conducted energy weapons occupy a unique position in the range of weapons available to police officers. They are clearly less lethal than firearms, yet the incidence of deaths proximate to their use suggests that they are potentially more lethal than more traditional intermediate weapons, such as batons, oleoresin capsicum (pepper) spray, or rubber bullets.

Their uniqueness, coupled with the controversy stemming from so many proximate deaths, has attracted the professional attention of scientific and medical researchers, who seek answers to questions such as, “Can the electrical current interfere with the subject’s cardiac or respiratory systems?” “If so, can that interference cause or contribute to death?” “If so, can we ascertain the risk?”

Those are precisely the questions that legislators, policy-makers, and police forces need answered in order to decide the circumstances, if any, in which conducted energy weapon use should be authorized.

In this part, I will discuss the medical and scientific research that has been done in Canada and internationally on conducted energy weapons, and summarize what we know and do not yet know about the risks associated with their use. I profess no special expertise in this highly technical area. I am indebted to the many experts from across North America who made presentations during our public forums, and to our Commission’s medical researchers (under the guidance of Dr. Keith Chambers), who undertook an exhaustive survey of the international academic literature. In the interests of transparency and to foster further understanding of these complex issues, a full bibliography of the literature surveyed is included in Appendix C and the complete text of those experts' presentations is available on the Commission's website.

B. CARDIAC RISKS

1. Immediate cardiac risks

a. Ventricular fibrillation

If conducted energy weapons cause or contribute to death, the most likely ultimate mechanism by which that occurs is ventricular fibrillation. The two lower chambers of the heart are the left and right ventricles. In order to sustain cardiac output for life, these bottom chambers of the heart need to contract in a regular, synchronized manner (*i.e.,* sinus rhythm). Ventricular fibrillation is a chaotic rhythm of these bottom chambers in which, according to Dr. Tseng,[155] the heart is not contracting, it is not pumping, it is just writhing in a discoordinated fashion—"the heart wriggles like a bag of worms." According to Dr. Kerr,[156] ventricular fibrillation causes the heart to beat at 200–300 beats per minute. The person will lose blood pressure, lose consciousness, and collapse within five to ten seconds. Dr. Tseng told me that this type of sudden cardiac death kills up to 450,000 Americans annually. It is universally fatal unless the rhythm is defibrillated into normal cardiac rhythm. One study determined that if defibrillation did not occur within two to four minutes, 50 percent of subjects suffered irreversible brain death. If defibrillation did not occur within 10 minutes, death was almost universal.

Ventricular fibrillation is caused by a disruption in the normal electrical current going to the heart muscle. This disruption can have an internal or external source. The

155 Transcript, May 9, 2008, p. 5.
156 Transcript, May 20, 2008, pp. 1-20.

disruption is most frequently internal, typically in people with heart disease. For example, a person who has had major heart attacks in the past will develop scar tissue in their heart and, when a stimulus is at a particular stage in the cardiac cycle, the electrical signal cannot go one way around the heart. It goes the other way, circles around the scar tissue and creates a very fast hemodynamically unstable rhythm, ventricular tachycardia, which may lead to ventricular fibrillation. It can also arise in people with hypertrophic cardiomyopathy (where the walls of the heart get very thick) or other congenital forms of heart disease.

Disruptions from an external source can be accidental or intentional. Electrocutions from household electrical current or from lightning are typical accidental external sources. So too are mechanical traumas to the chest wall, known as *commotio cordis.* For example, if a hockey puck or baseball strikes the chest at a vulnerable time during the heartbeat cycle, a healthy athlete may die suddenly from ventricular fibrillation.

Of particular interest to this Commission is the *intentional* external disruption of these electrical signals. Dr. Kerr and Dr. Tseng are both experienced cardiologists and electrophysiologists who devote much of their professional careers to installing pacemakers and implantable cardiac defibrillators into patients' chests. These defibrillators have a wire leading down into the heart. When the patient develops a life-threatening arrhythmia, the defibrillator will either pace the heart very rapidly and stop the arrhythmia, or shock the heart in order to bring the rhythm back to normal.

Dr. Kerr told me that they implant these defibrillators on an almost daily basis. In every case, they need to test it to ensure that it is working properly. They do this by intentionally inducing ventricular fibrillation through the introduction of tiny electrical shocks at the most vulnerable period of the cardiac cycle. The defibrillator recognizes the rapid beating as ventricular fibrillation, charges up its capacitors, and introduces an electrical shock to terminate the fibrillation.

According to Dr. Kerr, if a person is shocked externally, between 5 and 10 joules would be required in order to bring on ventricular fibrillation. However, in the case of an internal shock, only 0.2 to 0.5 joules is required.

Dr. Tseng explained the importance of timing, when a cardiologist intentionally induces ventricular fibrillation, by saying that a normal heartbeat can be divided into several discrete phases:

- *P-wave*—this represents contraction of the upper chambers of the heart (atria), which take blood from the veins of the body and feed the ventricles;
- *QRS*—this represents contraction of the ventricles, ejecting blood from the heart into the rest of the body or the lungs;
- *QT*—this represents the period of re-polarization, or electrical recovery of the ventricles; and
- *T-wave*—this represents the peak of this recovery period. The peak of the T-wave, which accounts for approximately 3 percent of the entire cycle, is the most vulnerable period. To induce ventricular fibrillation, a cardiologist delivers the electric shock at the peak of the T-wave.

i. Risks to subjects with healthy hearts

With that basic introduction to ventricular fibrillation, I turn now to an examination of whether the electrical current emitted from a conducted energy weapon is capable of inducing ventricular fibrillation and, if so, in what circumstances.[157]

In the discussion that follows, I will focus on deployment of conducted energy weapons in probe mode, in which two barbed darts are fired from the weapon become imbedded in the subject or their clothing, and a five-second pulsed electrical current is introduced to the subject's body via wires connecting the weapon to the barbs.

As I discussed in Part 3, the X26 conducted energy weapon delivers 19 electrical pulses per second, each pulse lasting for 80-100 millionths of a second. According to Mr. Reilly, the weapon has a peak output current of 3 amperes *(i.e.,* a measure of the

157 While most of the research to date has focused on the direct effect of a conducted energy weapon's electrical current in triggering ventricular fibrillation, there are other possible mechanisms that may be more causative, such as the possibility of a heightened adrenergic state causing ventricular fibrillation, or some other arrhythmia, such as bradycardia.

actual amperage during a pulse), and has a "delivered charge" for each pulse of approximately 100 micro-coulombs (100 millionths of a coulomb).

Several controlled laboratory experiments on pigs have focused on whether the electrical current from conducted energy weapons causes ventricular fibrillation:

- *McDaniel et al.*[158]—10 anesthetized pigs were subjected to five-second pulses discharged across the thorax from a custom-built device designed to deliver a discharge matching the waveform characteristics of the X26. The charge was increased until ventricular fibrillation was induced, at which point a decreasing series of discharges were applied until ventricular fibrillation was no longer induced by five discharges of equal charge. The researchers defined the maximum safe level as the highest discharge that could be applied five times without induction of ventricular fibrillation, from which a safety index was calculated. They calculated that a discharge that could induce ventricular fibrillation required at least 15 times the charge of the standard X26 discharge, increasing to 42 times in the case of increasingly heavy pigs. They concluded that the study confirmed the cardiac safety of such devices, that such devices may be safely applied multiple times if needed, and that discharge levels indicate an extremely low probability of inducing ventricular fibrillation.
- *Lakkireddy et al.*[159]—five anesthetized adult pigs were subjected to a series of discharges at increasing levels of charge, to determine at what level ventricular fibrillation would be induced. Electrodes were placed at five different locations on the thorax and back. After baseline testing, high-dose cocaine was infused intravenously. Researchers found that standard discharges (*i.e.,* at X26 level) did not cause ventricular fibrillation in any of the pigs at any of the five electrode locations, before or after cocaine infusion. However, they identified ventricular capture with electrodes placed nearest the heart, which suggests that the discharge may have overridden the heart's normal electrical current. The risk of ventricular fibrillation decreased as the electrodes were placed further and further away from the heart, and also decreased with cocaine infusion.
- *Nanthakumar*[160]—six anesthetized pigs were subjected to a total of 150 discharges from actual X26 and M26 weapons, in which the probes were placed either over the heart or the abdomen. Previous researchers had been

158 McDaniel, W.C., et al., "Cardiac Safety of Neuromuscular Incapacitating Defensive Devices," (2005), 28 Supplement 1 *PACE* S284.

159 Lakkireddy, D., et al., "Effects of Cocaine Intoxication on the Threshold for Stun Gun Induction of Ventricular Fibrillation," (2006) 48 *J. Am. Coll. Cardiol*. 805.

160 Nanthakumar, K., et al., "Cardiac Electrophysiological Consequences of Neuromuscular Incapacitating Device Discharges," (2006) 48 *J. Am. Coll. Cardiol*. 798.

unable to record electrical signals within the heart during the discharge, because the electrical "noise" from the weapon overwhelmed the electrocardiogram. To remedy that significant deficiency, these researchers inserted bipolar recording catheters into the right ventricle, and a blood pressure catheter was positioned in the descending aorta. They found that of the 94 discharges over the heart, blood pressure dropped to zero, and there was stimulation of the myocardium in 74 cases (79 percent), with a mean ventricular rate during stimulation and capture of 324 beats per minute. However, of the 56 discharges over the abdomen, there were no instances of myocardium stimulation. Put more simply, standard weapon discharge over the heart induced ventricular tachycardia (a precursor to ventricular fibrillation) four times out of five, but never in the case of discharge over the abdomen. In an attempt to simulate an excited state in these anesthetized pigs, the researchers infused them with epinephrine (adrenaline). In 16 discharges, there were 13 episodes of stimulation of the myocardium, including one case of ventricular fibrillation.

- *Dennis*[161]—six anesthetized pigs were subjected to two 40-second discharges from an X26 weapon. Dart placement traversed the left thorax. To assess the rhythm and function of the myocardium, echocardiography was performed. Two animals died from ventricular fibrillation, and most of the others "showed capture of ventricular rhythm with rapid ventricular contractions seen on echo consistent with ventricular tachycardia (approximate rate of 300 bpm)." The researchers stated that their observations were in general agreement with those of Nanthakumar, discussed above.
- *Walter*[162]—the same team of researchers as in *Dennis* subjected eight anesthetized pigs to two 40-second discharges from an X26 weapon, with the darts placed along a transcardiac vector. The pigs were monitored with an ECG and echocardiography. All eight animals showed rapid cardiac rhythm and significant decline in systolic function that was consistent with ventricular fibrillation/flutter (301 beats per minute). One animal died from ventricular fibrillation, while two others experienced ventricular tachycardia/flutter, which reverted spontaneously to a normal rhythm within 17 seconds of cessation of the discharge. The researchers concluded that ventricular tachycardia/flutter occurs immediately upon starting the weapon discharge and invariably in all animals regardless of body mass, using darts more than 5 cm from the heart. Consequently, there is no safety factor for ventricular tachycardia, and a moderate likelihood of fatal ventricular fibrillation (one in eight animals tested) with the transcardiac vector used in this study.

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161 Dennis, A. J., et al., "Acute Effects of TASER X26 Discharges in a Swine Model," (2007), 63 *TRAUMA* 581.

162 Walter, R.J., et al., "TASER X26 Discharges in Swine Produce Potentially Fatal Ventricular Arrhythmias," (2008) 15 *Acad. Emerg. Med*. 66.

- *Webster*[163]—some researchers questioned whether pig study results could be extrapolated to humans, because pigs (but not humans) have a thick band of muscles across the chest that may affect electrical conductivity. To address this concern, these researchers modified dart placement. In their first study of 10 anesthetized pigs, a dart was inserted into the chest and, after each X26 discharge, the dart was moved closer to the heart. They determined that, on average, ventricular fibrillation occurred when the dart was 17 mm from the heart. In their second study (which eliminated a gel that had been applied to fill the air gap around the dart plunger), they determined that ventricular fibrillation occurred, on average, when the dart was about 6 mm from the heart. Mr. Webster told me that "if a 9 mm dart goes into a human that has 11 mm distance [between skin and heart], these data suggest that under those conditions the human would be electrocuted."[164] He stressed that the dart would have to land in a very small area of the chest, between the ribs. The researchers undertook a statistical analysis of several variables (including real-life dart placement locations based on data provided from the manufacturer and variations in skin-to-heart distances in the general population), from which they concluded that the probability of ventricular fibrillation from use of a conducted energy weapon was about six in a million. Mr. Webster also told me that during their testing many discharges caused ventricular tachycardia (rapid heartbeats in an abnormal rhythm), that were resolved either by returning to normal or progressing to ventricular fibrillation several minutes later.

While researchers often rely on animal studies because of ethical objections to experiments on humans (and prefer using pigs because of their anatomical and physiological similarities to humans), they readily acknowledge the inherent limitations in pig studies because of crucial anatomical and electrophysiological differences between pigs and humans, which calls for caution in making extrapolations to humans. For that reason, attempts have been made to study the effect of conducted energy weapons on humans, in ethically acceptable settings.

Dr. Jeffrey Ho, a specialist in emergency medicine, made a presentation at our public forums. He told me that he has conducted several studies on the effect of conducted energy weapons on human volunteers:

163 John G. Webster, Transcript, May 5, 2008, p. 62.
164 *Ibid*., p. 68.

- In a 2006 study,[165] they sought to determine if there was evidence of induced electrical dysrhythmia or direct cellular damage that would indicate a causal relationship between application of an X26 and in-custody death. Sixty-six adult volunteers recruited at a TASER International training course were subjected to one 5-second discharge in their backs from an X26. Thirty-two of them underwent electrocardiographic evaluation immediately before and after (but not during) the discharge, and 16 and 24 hours later. They found that the weapon discharge did not affect the recordable cardiac electrical activity within the 24-hour period.
- In a 2007 study,[166] a baseline electrocardiogram was obtained from 25 adult volunteers, who were then put through a physical regimen of push-ups and treadmill sprints to simulate the physical exertion often seen in real-life scenarios. They then received a continuous 15-second discharge from an X26 on their thoraces, either in their front or in their back. Electrode positions involved at least a 12-inch spread and always encompassed the normal anatomic position of the heart. An electrocardiogram was obtained after exposure. They found that in all cases, exposure did not cause a detectable change in the electrocardiogram.
- In a 2008 study,[167] the researchers noted that some animal model research supported the hypothesis that conducted energy weapons can cause dangerous cardiac rhythms, recording supposed cardiac capture rates of 300 beats per minute. They attempted to recreate these animal research conditions in humans. The study involved 33 human volunteers recruited at several TASER International training courses in 2007. They underwent echocardiography before, during, and after 10-second X26 applications, with thoracic skin surface electrodes placed in the optimal cardiac axis position (upper right sternum and cardiac apex as estimated by the palpated point of maximal impulse). Ultrasound images were analyzed using M-mode through the anterior leaflet of the mitral valve for evidence of arrhythmia. Although the mean heart rate increased from 109 to 120 beats per minute during exposure, no adverse events were recorded. Sinus rhythm was clearly demonstrated in 21 of 33 subjects during exposure, but not in the other 12 due to movement artifact. There were no episodes of ventricular tachyarrhythmia. The authors noted that there have been over 700,000 conducted energy weapon discharges during the manufacturer's training classes, with no reported collapses, cardiac arrests, or fatalities, from which

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165 Ho, J., et al., "Cardiovascular and Physiologic Effects of Conducted Electrical Weapon Discharge in Resting Adults," (2006) *Acad. Emerg. Med*. I.

166 Ho, J., et al., "Absence of Electrocardiographic Change Following Prolonged Application of a Conducted Electrical Weapon in Physically Exhausted Adults," (2007) SAEM Annual Meeting Abstracts #322, p. S128.

167 Ho, J., et al., "Echocardiographic Evaluation of a TASER-X26 Application in the Ideal Human Cardiac Axis," (2008) 15 *Acad. Emerg. Med*. 838.

they concluded, "the possibility of [conducted energy weapon] induced arrhythmia seems extremely unlikely."

Researchers from the University of California, San Diego's Department of Emergency Medicine have conducted several human tests:

- *Levine*[168]—105 adult volunteer law enforcement officers were subjected to a single X26 discharge of up to five seconds (average shock duration was three seconds) into their backs. The researchers concluded that "a significant increase in heart rate was found after a brief shock … [but] there were no other identified cardiac rhythm disturbances or morphology changes except for a few subjects who appeared to have QT changes, the significance of which is unclear."
- *Vilke*[169]—32 healthy police volunteers were subjected to an X26 discharge of up to five seconds (average was 2.1 seconds). Alligator clips were attached to each subject's clothing instead of the weapon's normal barbs, and the report does not specify whether they were attached in the chest or back area. An ECG was taken five minutes before exposure and one minute after exposure, but not during exposure. There was an increase of 2.4 beats per minute in mean heart rate, but there were no instances of dysrhythmia or ectopy for any subject. The researchers concluded that "we found no clinically significant changes in cardiac interval changes, including QTc, PR, or QRS immediately after a TASER activation."

During our public forums, Dr. Tseng told me about a reported case[170] in which a prison inmate with a pacemaker implanted in his left chest was subjected to a conducted energy weapon discharge into his right chest area. When the pacemaker data was analyzed, there was clear evidence of weapon-induced myocardial capture—two high ventricular rate episodes (240 beats per minute) corresponding to the exact time of the weapon application.[171] Dr. Tseng said that in the case of implanted defibrillators, there is a risk that the defibrillator may interpret the weapon's pulses as abnormal

168 Levine, S.D., et al., "Cardiac Monitoring of Human Subjects Exposed to the TASER," (2007) 33 *J. Emerg. Med*. 113.

169 Vilke, G.M., et al., "Twelve-lead Electrocardiogram Monitoring of Subjects Before and After Voluntary Exposure to the TASER X26," (2008) 26 Am. *J. Emerg. Med*. 1.

170 Cao, M., et al., "TASER-Induced Rapid Ventricular Myocardial Capture Demonstrated by Pacemaker Intracardiac Electrograms," (2007) 18 *J. Cardio. Electro*. 876.

171 Drs. Tseng and Kerr cautioned that one cannot be sure from the data available in this case whether the pulse from the weapon stimulated the heart directly, or whether the electrical charge from the weapon collected on the wire running from the pacemaker into the heart and ran down the wire to stimulate the heart.

cardiac rhythm, and may shock the patient because of the weapon, not because of any dangerous heart rhythm.

From this review, I have drawn several conclusions.

First, there can be no doubt that an external electrical current can overtake the human body's internal electrical system, resulting in ventricular capture, which may lead to ventricular tachycardia and, in some cases, ventricular fibrillation. Cardiologists routinely introduce small electrical shocks for the purpose of triggering ventricular fibrillation, in order to test newly implanted defibrillators.

Second, there is some evidence that the electrical current from a conducted energy weapon is capable of triggering ventricular capture. The real-life example of a man with a pacemaker having a conducted energy weapon applied against him, resulting in myocardial capture corresponding exactly to the timing of the weapon's pulses, is persuasive evidence that the weapon's electrical current can override the heart.

Third, human studies conducted to date, by researchers such as Drs. Ho, Levine, and Vilke, have not yielded evidence of ventricular tachyarrhythmias. However, I am reluctant to generalize from their studies, for several reasons. They frequently applied the electrical shock to the subject's back as opposed to the chest area, clipped the electrodes to the subject's clothing or taped them to the skin rather than using barbs that penetrate the skin, and in some cases restricted the discharge to 2–3 seconds. More importantly, most of those studies were not capable of ascertaining whether there was an arrhythmia *during* the weapon's discharge. In one study, the researchers were able to determine that 21 subjects who were monitored by echocardiography had normal heart rhythms during discharge, but that is far too small a sample from which to draw conclusions about whether a weapon is capable of causing ventricular capture and, if so, how frequently.

Fourth, we do know from several animal studies that a conducted energy weapon's discharge can trigger ventricular tachycardia and/or fibrillation in pigs. I approach these studies with caution, recognizing the differences between pigs and humans.

Having said that, I am satisfied that it is safe to draw several conclusions from these studies that can be extrapolated to humans. First, the greatest risk of ventricular fibrillation arises when the probes are vectored across the heart. Second, the risk of ventricular fibrillation increases as the tips of the probes get closer to the wall of the heart.

Fifth, I am satisfied that there is a short "window" during the heart's normal beat cycle (the T-wave), when the heart is most vulnerable to an external electrical shock. Fibrillation is known to occur when athletes receive a blow to the sternum during the T-wave, and when cardiologists test newly implanted defibrillators, they time their electrical charge to coincide with the T-wave.

Sixth, while induction of ventricular fibrillation may be dependent on timing of discharges within the vulnerable period of the cardiac cycle, that "narrow window" does not apply to rapid ventricular capture causing ventricular tachycardia, a hemodynamically unstable rhythm which may degenerate into ventricular fibrillation. Death in these circumstances may not be immediate. Ventricular tachycardia is not dependent on timing within the cardiac cycle—discharges at almost any time in the cardiac cycle can capture the heart to cause ventricular tachycardia.

Seventh, while I have concluded that a conducted energy weapon is capable of triggering ventricular capture that may lead to ventricular tachycardia and/or fibrillation, I do not have enough information to quantify that risk with any degree of precision. Further, the risk appears to vary, depending on several factors, which I will discuss later in this part.

Eighth, in deaths proximate to use of a conducted energy weapon, there is often a lack of physical evidence on autopsy to determine whether arrhythmia was the cause of death, which opens the door to debate about whether the weapon or some pre-existing medical condition was responsible. While alcohol or drug intoxication may complicate the pathological analysis in some cases, other explanations must be found in cases where alcohol or drugs were not involved. Several medical experts who made oral presentations during our public hearings emphasized that there must be some explanation for these sudden deaths:

- **Dr. Charles Kerr**—"But the one thing I think is clear is that people have had cardiac arrests, and the majority of times there's no obvious structural heart disease or other cause of death, no bleeding or head trauma. And if somebody dies suddenly and no obvious cause, that is almost certainly an arrhythmia, an abnormal heart rhythm, either an excessively fast abnormal heart rhythm or a slow one."[172]
- **Dr. Zian Tseng**—"If you see no finding on an autopsy that supports a related arrhythmic death. If there's a person that dropped dead suddenly after TASER application and you can find nothing else on autopsy, I would venture to say that that's due to an arrhythmic death."[173]
- **Dr. Michael Janusz**—"If someone is tasered in the front of the chest and immediately falls to the ground and is unresponsive, it is almost certainly ventricular fibrillation, and cardiopulmonary resuscitation and defibrillation are required."[174]

Before moving on to an examination of circumstances in which the risk may increase, I would like to comment on a statistic cited by one of the medical researchers, that there have been over 700,000 conducted energy weapon discharges during the manufacturer's training classes, with no reported collapses, cardiac arrests, or fatalities. On its face, this is an impressive record of safety. However, I approach this data with caution for the following reason. The information before me points to the *capacity* of a conducted energy weapon to cause heart arrhythmia even in healthy adults, but the risk varies depending on the existence of several factors, such as the location of the probes (*i.e.,* across the heart), the timing of the discharge (*i.e.,* during the T-wave), the proximity of the tip of the probe to the heart wall, and the duration of the discharge.

As the animal studies have shown, the likelihood of triggering ventricular fibrillation increases dramatically as some of these variables are manipulated. It follows that the converse is true as well, and the risk of ventricular fibrillation decreases if, for

172 Transcript, May 20, 2008, p. 18.
173 Transcript, May 9, 2008, p. 27.
174 Transcript, May 20, 2008, p. 25.

example, the probes are kept away from the heart and the duration of the discharge is shortened. The dilemma facing researchers using human subjects is to obtain useful data without exposing their volunteers to undue risk. Similarly, those who deploy weapons against police officers during training want to give their subjects a real-life experience, without exposing them to undue risk. Consequently, it is not surprising that the manufacturer has published guidelines[175] for how its weapons should be deployed during instructor training, which include the following:

- The actual barb and probe body is removed, and the ends of the wires are taped to the volunteer's body;
- The two wires are taped to parts of the body distant from the heart, such as a foot and hip, a shoulder and hip or the upper and lower back; and
- The weapon is discharged for 1–2 seconds, which is "ample enough time to experience the effects first hand."

I understand entirely the reasons for this precautionary approach—giving police officers an opportunity to experience the weapon's discharge, but according to a protocol that minimizes the risk of triggering a cardiac arrhythmia. But it is this very protocol that makes the resulting data of very limited value when ascertaining the weapon's capacity to cause harm. The protocol deliberately excludes the very factors that create the risk, such as avoiding a vector across the heart, not allowing the probes to deploy into the chest area (which would reduce the probe tip-to-heart distance), and shortening the duration of the discharge.

This data does suggest that the risk of ventricular fibrillation can be reduced, and perhaps even eliminated, if probes are kept away from the heart and attached to the surface of the skin, and if the duration of the discharge is reduced to less than half of the standard five-second cycle. But I do not find this data of any assistance when considering the *capacity* of a conducted energy weapon to trigger cardiac arrhythmia.

175 TASER International Instructor Training Bulletin, "Mandatory Hits with the ADVANCED TASER," M26 Instructor course materials, Version 11.

ii. Circumstances in which the risk may increase

Heart disease

Several cardiologists told me that people with cardiovascular disease are at a significantly higher risk of ventricular fibrillation. Dr. Janusz said:

> It is really quite difficult to cause a normal heart to fibrillate. When we have the chest open at surgery, you can pick the heart up, look at the vessels on the back, touch it with your hand, touch it with the cautery. It'll have the odd extra beat but that doesn't cause any problem. By contrast, in a really sick heart, we are very cautious to avoid touching the ventricle until we are on bypass so that it will have the support of the circulation in case it fibrillates.[176]

To the same effect, Dr. Kerr explained that scar tissue formed by previous heart attacks could cause abnormal circular "re-entry" currents that travel around the heart instead of from top to bottom, potentially causing disorganized rhythms leading to ventricular tachycardia or fibrillation.

I also learned that the shock and intense pain that a subject experiences when a conducted energy weapon is discharged is more dangerous when the subject has cardiovascular disease, because the heart may beat faster and more forcefully, placing greater strain on the heart wall. People with chronic high blood pressure may undergo a dramatic increase in blood pressure, leading to ventricular fibrillation. People with weakly pumping hearts (*e.g.,* congestive heart failure) may be unable to tolerate the faster heartbeat for long, with the same outcome.

Heart disease not only increases the risk of ventricular fibrillation, but also affects resuscitation. Dr. Janusz states, "Unfortunately, patients with underlying heart disease will also be the most difficult to resuscitate after ventricular fibrillation."[177]

In light of this medical evidence, it is not surprising that in 2007 the manufacturer published a product warning that stated in part:

> **Avoid Known Pre-Existing Injury Areas**—when practical, avoid deploying a TASER device at a known location of a pre-existing injury (*e.g.,* avoid targeting

176 Transcript, May 20, 2008, p. 23.

177 Transcript, May 20, 2008, p. 24.

> … the chest area on persons with a known history of previous heart attacks, etc.). These injuries may be provoked by such deployment.[178]

However, the April 28, 2008, version of this product warning removed any specific reference to cardiac risks, cautioning users only that "when practical, avoid deploying or using a TASER device on a known area or location of pre-existing injury without legal justification. Pre-existing injuries may be exacerbated by such deployment." The manufacturer published, contemporaneously, a training bulletin that stated in part:

> The preponderance of the data, including all of the human studies, suggests that VF [ventricular fibrillation] is not caused by ECDs [electronic control devices] in real-world usage. There is no evidence of important electrocardiogram changes, or capture (pacing response of the heart to electrical stimulation), and finite element modeling does not suggest a current density in real-world use able to induce fibrillation in humans. Also, epidemiological studies do not find that real-world human ECD use causes VF.[179]

It may be true that human studies have not documented instances of ventricular fibrillation following discharge of a conducted energy weapon. However, that speaks to a different issue than what is under consideration here—whether a conducted energy weapon *is capable* of triggering cardiac capture that may lead to ventricular tachycardia and/or fibrillation. In one reported case,[180] a conducted energy weapon was used to subdue an adolescent, who subsequently collapsed. Paramedics found the adolescent to be in ventricular fibrillation and began performing cardiopulmonary resuscitation within two minutes of the collapse, and a perfusing rhythm was restored.

I am persuaded, from the information before me, that a conducted energy weapon is capable of triggering cardiac capture, and that the risk increases in the case of subjects with pre-existing cardiovascular disease.

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178 "Product Warning—Citizen," March 1, 2007, p. 2.

179 Training Bulletin 14.0-03 TASER Law Enforcement Warnings, April 28, 2008.

180 Kim, Paul J. and Wayne H. Franklin, "Ventricular Fibrillation after Stun-Gun Discharge," 353 *New England J. Med*. 9 (2005).

Body size or shape

In one animal study, it was found that the conducted energy weapon discharge that was required to induce ventricular fibrillation increased significantly in the case of increasingly heavy pigs.[181] However, size may be relevant only insofar as a larger subject will probably have a greater skin-to-heart distance. As Webster demonstrated,[182] the likelihood of ventricular fibrillation increased as the tip of the weapon's dart moved closer and closer to the heart. Another researcher, who had conducted a similar porcine test in which he found that the average dart tip-to-heart distance to induce ventricular fibrillation was 17 mm, measured the skin-to-heart distance of 150 adult human volunteers. He found that 42 percent had a skin-to-heart distance of 26 mm or less, which made them potentially vulnerable for ventricular fibrillation, assuming that the tip of the dart penetrated the full 9 mm into the chest.[183]

Subject's physical response

There is some evidence to suggest that the way in which a subject responds to a conducted energy weapon discharge may increase the risk of ventricular fibrillation.

No one disputes that, in addition to incapacitation, discharge of a conducted energy weapon produces intense pain, often coupled with anxiety, distress, and a physical struggle with police officers. According to Dr. Kerr:

> [W]hen people have pain, anxiety, distress, they will have an outpouring of their central nervous system, what we call the sympathetic nervous system, that stimulates the heart. There's also an outpouring from the adrenal glands of adrenaline and other compounds like adrenaline, and they also directly stimulate the heart. They cause the heart to go faster, they cause the blood pressure to go up, and they also alter the electrical properties of heart muscle cells by changing the voltages across the cell membranes that make them more prone to developing dangerous arrhythmias.[184]

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181 *Ibid.,* footnote 158.

182 *Ibid.,* footnote 163.

183 Rahko, P., "Evaluation of the Skin-to-Heart Distance in the Standing Adult by Two-Dimensional Echocardiography," (2008) 21 *J. Am. Soc. Echocard*. 761.

184 Transcript, May 20, 2008, p. 7.

Dr. Swerdlow agreed, stating during his presentation that "as electrophysiologists and other cardiac experts, we know that adrenaline makes you more vulnerable to fibrillation as a serious arrhythmia and cause of death."[185]

In his 2006 animal study,[186] Dr. Nanthakumar demonstrated that relationship. He found that when epinephrine (adrenaline) was induced during weapon discharges across the heart, the myocardium was stimulated in 13 out of 16 pigs, one of which resulted in ventricular fibrillation.

This type of exertion (involving skeletal muscle contractions) may also result in the buildup of lactic acid and carbon dioxide in the blood, which lowers the blood pH, thereby increasing acidity, which may lead to acidosis.[187] Normal blood pH varies between 7.35 and 7.45, but may drop to 7.2 or 7.0, or even lower in the case of acidosis. Acidosis affects the electrolyte balance, especially potassium, and the electrical triggering of the heart, making the heart more susceptible to ventricular fibrillation.[188]

Sometimes the intense muscle contractions brought about by the conducted energy weapon discharge causes muscle damage (rhabdomyolysis), contributing to an increase in potassium levels that may electrically imbalance the heart.

When acidosis occurs, it can take some time for the blood's pH level to return to normal. Dr. Tseng told me that, because of this, one cannot eliminate ventricular fibrillation as a possible cause of death just because death did not immediately follow discharge of a conducted energy weapon:

> Also I'll say that delayed sudden death doesn't mean that the TASER shock was not contributory. You've seen that the TASER causes QT changes. It causes acidosis. It causes pain and adrenaline. And those effects persist for minutes. So if you have a sudden death ten minutes later, twenty minutes later, that

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185 Transcript, June 25, 2008, p. 31.

186 *Ibid.*, footnote 160.

187 *Ibid.*, footnote 161, p. 588.

188 Jauchem, J.R., et al., "Acidosis, Lactate, Electrolytes, Muscle Enzymes, and Other Factors in the Blood *Sus scrofa* Following Repeated TASER Exposures," (2006) 161 *Forensic Science Intl.* 20, at 27.

> doesn't mean that the TASER twenty minutes ago didn't contribute to the death.[189]

Timing of the shock

While a sufficient external electrical current is capable of triggering ventricular fibrillation at any time during a normal heartbeat cycle, it does not appear to be in dispute that this risk increases significantly if the discharge of the external electrical current coincides with the cycle's T-wave peak. Odell states:

> Current pulses which might merely produce an extrasystole if present at other portions of the cycle may induce fibrillation during the T-wave with a threshold 25 or more times lower than at other times in the cycle[190] [emphasis added].

There is, of course, no way for a conducted energy weapon operator to tell what part of a heartbeat cycle a subject is in when the weapon is deployed.

b. Myocardial infarction (heart attack)

Coronary heart disease is caused by a blockage of the arteries that supply blood to the heart muscles. During our public forums, Prof. Savard described the process as follows:

> Now, for the abnormal state we'll talk about coronary heart disease, which is a narrowing of the arteries that irrigate the heart muscle itself. So this narrowing occurs because of plaque, because of atherosclerosis. If you have partial occlusion (*i.e.,* blockage) in the myocardium, the muscle under the occlusion does not receive enough blood, you have a state of ischemia. The muscle is still alive but is like choking. But if you have a complete occlusion, then the tissue, the muscle will die, will be replaced by scar tissue. It's called myocardial infarction.[191]

Another cause of myocardial infarction is electrical injury. In one case, a construction worker was diagnosed with inferior wall myocardial infarction after a crane boom

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189 Transcript, May 9, 2008, p. 28.

190 Odell, M., "The Human Body as an Electric Current," (1997) 4 *J. Clin. For. Med*. 1, at 5. He cites, for this proposition, the International Electrotechnical Commission, *Effects of Current Passing Through the Human Body*, Document 479-1, IEC, 1984.

191 Transcript, May 22, 2008, p. 4.

came in contact with a high tension line rated at 23,000 volts. In a case report,[192] the attending physician cited numerous other reported instances, but characterized the phenomenon as "uncommon."

In an animal study comparing AC and DC current, researchers found a 90 percent incidence of myocardial infarction with AC current, and a 33 percent incidence with DC current. After citing these results and after discussing real-life instances of myocardial infarction following electrical injury, the researchers stated that the absence of atherosclerosis made coronary spasm a likely cause of this myocardial damage: "The proposed mechanism of injury is prolonged coronary artery spasm, perhaps tetanic in nature, induced by the alternating current."[193]

Another researcher, after reviewing numerous previous studies, was more cautious, emphasizing that appropriate treatment will depend on an accurate diagnosis of the cause of the cardiac arrest:

> A specific therapy does not exist; however, victims with cardiac arrest from electrical shock or lightning strike require prompt, aggressive resuscitation. Treatment of myocardial necrosis requires drugs to reduce platelet aggregation and heparin; Ca-antagonist (in no heart failure cases) and nitrate may be helpful to reduce coronary spasm. Hypertension, heart failure or conduction abnormalities required standard therapeutic regimens. However, in managing apparent acute myocardial infarction, the possibility that injury is not of ischemic origin must be considered.[194]

While studies have not yet examined whether the electrical current from a conducted energy weapon is sufficient to trigger coronary spasm, it is possible that such a mechanism exists.

A further possible cause of myocardial infarction associated with use of a conducted energy weapon is stress. The anxiety felt by subjects before a discharge, the intense pain experienced during discharge, and the exertion that often follows discharge

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192 Kinney, T.J., "Myocardial Infarction Following Electrical Injury," (1982) 11 *Annals Emerg. Med*. 622.

193 Robinson, N.M.K., et al., "Electrical Injury to the Heart May Cause Long-term Damage to Conducting Tissue: A Hypothesis and Review of the Literature," (1996) 53 *Intern. J. Cardiol*. 273.

194 Fineschi, V., et al., "Electric Shock: Cardiac Effects Relative to Non-fatal Injuries and Post-mortem Findings in Fatal Cases," (2006) 111 *Intern. J. Cardiol*. 6.

(during attempts at restraint) inevitably increase the heart rate and, with it, a greater oxygen demand. Subjects with pre-existing coronary artery disease have a significantly reduced capacity to supply the heart muscle with oxygen-rich blood, which may lead to ischemia or in severe cases, myocardial infarction. Dr. Kerr cautioned that:

> [P]eople can have absolutely amazing intensification of their sympathetic nervous system under stressful situations. People can jack their heart rates up to 180, 200 beats a minute in a tense environment. Their blood pressures can go up to 200, 240 millimetres of mercury sometimes in these kinds of environments. And the intense stimulation that that causes the heart—I don't think can be underestimated.[195]

c. Pacemakers and defibrillators

Permanent pacemakers deliver tiny electrical impulses to the heart, to regulate abnormally fast, slow, or irregular heartbeats. Implanted cardioverter defibrillators also deliver electrical currents to the heart to correct fibrillations and other arrhythmias. Both devices deliver their currents directly into the heart by way of metal leads running from the devices into the heart muscles. Researchers have raised several concerns:

- These wires might conduct the current from a conducted energy weapon directly into the heart, in which case much less current would be required to trigger a life-threatening arrhythmia.
- The weapon's current might override the pacemaker's current. That effect was demonstrated in one case discussed earlier, in which a prison inmate with an implanted pacemaker received a conducted energy weapon discharge, and data retrieved from the pacemaker showed a very high heart rate (tachycardia) driven by every third weapon pulse. Dr. Kerr mentioned this case during his oral presentation, and cautioned that it was not clear whether the weapon's current stimulated the heart directly or the weapon's current collected on the wire and travelled down the wire, stimulating the heart.
- The device might interpret the weapon's current as ventricular fibrillation, causing the defibrillator to emit an electrical current inappropriately.

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195 Transcript, May 20, 2008, p. 13. According to one cardiologist, this intense blood pressure can also trigger the rupture of an atherosclerotic plaque to induce myocardial infarction.

Dr. Tseng identified this as a concern. In one case, the female subject of a five-second weapon discharge wore an implanted cardioverter defibrillator. After the incident, data from the device revealed one episode of ventricular fibrillation which corresponded to the time of the weapon discharge. The device's capacitor charged up in preparation for ventricular fibrillation therapy, but by the time that the device attempted to reconfirm fibrillation, the weapon discharge had ceased and the device no longer detected fibrillation, so the charged energy was diverted. The researchers found no damage to the device, but added: "A longer exposure time to the TASER energy or a shorter capacitor charging time due to lower shock energy programmed (i.e., 20 J) could have led to a shock delivery by the ICD."[196]

- The weapon's current might damage the device. According to one researcher, "electromagnetic interference can result in many undesirable consequences, including damage to internal circuitry, oversensing, undersensing, failure to pace, failure to capture, power on reset, triggering of elective replacement indicators and inappropriate defibrillation therapy."[197] However, his test of nine pacemakers and seven defibrillators on a pig, with a standard five-second weapon shock over the heart, found no damage to the devices. He stated, at page 555:[198]

> Our results indicate that there was no change in the integrity of pacing and sensing functions of both the ICD [implantable cardioverter defibrillator] and the PM [pacemaker] leads. There was no immediate damage to implanted pacemakers' and defibrillators' generators caused by the standard NMI [neuromuscular incapacitation] discharge. A 5-second NMI discharge did not seem to be detrimental to pacemaker or ICD lead function and integrity acutely. Our experimental design, of course, could not exclude the potential that repeated applications of these shocks may cause cumulative damage to the generators or that single applications may lead to long-term malfunction of these devices.

From this review I conclude that there are several risks associated with deployment of a conducted energy weapon against a subject who is wearing an implanted pacemaker or defibrillator. For example, the weapon's current may collect on the device's wire and travel directly into the heart (in which case significantly less current may be

196 Haegeli, L.M., et al., "Effect of a TASER Shot to the Chest of a Patient with an Implantable Defibrillator," (2006) 3 *Heart Rhythm* 339.

197 Lakkireddy, D., et al., "Do Electrical Stun Guns (TASER-X26) Affect the Functional Integrity of Implantable Pacemakers and Defibrillators?" (2007) 9 *Eurospace* 551. See also Lakkireddy, D. et al., "Can Electrical-Conductive Weapons (TASER) Alter Functional Integrity of Pacemakers and Defibrillators and Cause Myocardial Capture?" Abstract, Heart Rhythm Society, 29th Annual Meeting, May 2008.

198 *Ibid.*

required to trigger a life-threatening arrhythmia), or the device may wrongly interpret the weapon's current as ventricular fibrillation and respond inappropriately.

In the light of these risks, it is in my view imprudent for law enforcement agencies in British Columbia to train in accordance with the part of the manufacturer's current training materials that states:

> Modern pacemakers and implanted defibrillators withstand external electrical defibrillators at least 800 times stronger than the TASER conducted energy pulses…. Published peer reviewed research shows that there is no negative effect of the TASER device when used on a subject with an implanted device.

It is not surprising that these devices can withstand the current from a defibrillator—one would hope that those who design these devices would build such safety margins into the devices in anticipation that a person wearing a device might need to be externally defibrillated. The issue before me is different—is a person wearing one of these devices at greater risk if they receive a discharge from a conducted energy weapon? The information before me strongly suggests that they are, and that risk should be addressed in the training that officers receive.

Unquestionably, we could benefit from further research. Mr. Reilly told me:

> But there could be other things that ought to be looked at and I think, for instance, implanted pacemakers and implanted defibrillators would certainly be things on our list of things that we need to understand better, whether the function of those devices might be interfered with. And that's the question that needs to be raised, and I don't have an answer for it.[199]

d. Blood pressure

Several researchers have found that a subject's heart rate increased, either before, during, or after a conducted energy weapon discharge. An increase in heart rate leads to increased blood pressure, which can cause acute stroke or create several other problems:

- *Rupture of a pre-existing aneurysm*—an aneurysm is an abnormal ballooning of the wall of an artery, which makes the wall thinner and more

199 Transcript, May 5, 2008, p. 58.

brittle, and thus prone to rupture in the event of a sudden increase in heart rate and blood pressure. Rupture of a major artery such as the aorta can cause massive internal hemorrhaging and loss of blood pressure, which can lead to death.

- *Rupture of the heart wall*—a similar risk exists in areas of the heart wall where coronary heart disease has created scar tissue, so that the heart wall is thinner and more brittle.
- *Petechiae*—these are pinpoint bruises usually affecting the eyelids and the clear membrane covering the white part of the eyeball (conjunctiva). Petechiae are traditionally associated with asphyxia deaths, but a decade ago one researcher questioned that relationship, given the absence of petechiae in many such deaths. Her review of the literature led her to conclude that "petechiae of the head are the product of purely mechanical vascular phenomena; namely impaired or obstructed venous return in the presence of continued arterial output."[200] This phenomenon may have some relevance to the use of conducted energy weapons for the following reason: if the deployment of a weapon and any resulting struggle causes an increase in blood pressure, and if compressive pressure to the subject's chest or neck during restraint is great enough to obstruct venous return from the head but not enough to obstruct arterial flow to the brain, then cephalic venous pressure will rise, resulting in petechiae.

2. Delayed cardiac risks

Can a conducted energy weapon be responsible, if a subject dies some time after the conducted energy weapon was discharged?

Based on the information before me, one can envisage scenarios in which a conducted energy weapon may contribute to a subject's death, even though that death appears to have occurred some time after deployment of the weapon. For example:

- The weapon's current might cause an implanted cardioverter defibrillator to interpret the weapon's externally generated current as ventricular fibrillation, leading the device to respond inappropriately after charging up its capacitor. I accept that such an inappropriate discharge would rarely cause death.
- In the case of subjects with coronary heart disease, stress brought on through deployment of the weapon (and post-discharge efforts at restraint) may lead to increased heart rate and blood pressure, leading to subsequent myocardial infarction and/or rupture of a pre-existing aneurysm.

200 Ely, S., et al., "Asphyxial Deaths and Petechiae: A Review," (2000) 45 *J. Forensic Sc*. 1274.

Those phenomena may be identifiable during an autopsy, providing an evidentiary basis for the pathologist to conclude that the weapon's electrical current may have been the triggering event.

However, the human body may react to a conducted energy weapon discharge in a way that does not leave physical evidence that would be available to a pathologist during an autopsy. For example, several presenters told me that stress produces adrenaline, which causes the heart to race, increases blood pressure, and changes voltages across heart cell membranes, making a person more susceptible to ventricular fibrillation, either directly, or indirectly through acidosis. When acidosis occurs, it can take some time for the blood's pH level to return to normal and, because of this, one cannot eliminate ventricular fibrillation as a possible cause of death just because death did not immediately follow discharge of a conducted energy weapon.

Similarly, some studies have demonstrated a progression from ventricular tachycardia to ventricular fibrillation over several hours.

Finally, death may have occurred earlier than observers think. Dr. Janusz explained this as follows:

> And an acute condition where you have a low cardiac output and a low blood pressure, so a partially perfused brain will often cause seizures. That won't go on all that long after the condition proceeds to ventricular fibrillation because all cerebral activity will stop within a minute or so. But you'll see a patient, or a victim, lying on the ground thrashing around, and may not recognize that the heart has stopped, because he's still moving. Agonal gasping reflex is something that's present frequently or universally after cessation of flow to the brain and it's a trigger in the brain stem that causes an attempt to take a big breath. So that if you observe somebody who has just expired and watch for a minute or two or three or five minutes, you will see every so often an attempt at a large breath. And if you had someone lying on the ground and he wasn't really being examined carefully and they saw a respiratory effort from time to time, they might conclude that he was breathing, whereas in fact the cardiac arrest had occurred a few minutes before.[201]

201 Transcript, May 20, 2008, pp. 27-28.

I am satisfied that there are some circumstances in which a conducted energy weapon may have caused or contributed to a death, even though the death occurred (or appeared to occur) some time after the weapon was discharged.

C. RESPIRATORY RISKS

Human life is as dependent on the lungs as it is on the heart. The lungs perform two principal functions. They extract carbon dioxide from the blood and expel it from the body through the mouth, and they infuse the blood with oxygen, which is then circulated to cells throughout the body.

Breathing or respiration facilitates these exchanges, and breathing results from the regular contraction and relaxation of the intercostal muscles around the rib cage and the thoracic diaphragm, a sheet of muscle separating the thoracic cavity from the abdominal cavity.

If breathing ceases, the body's vital organs are starved of oxygen. The heart stops beating, the brain stops functioning, and death soon ensues.

The intercostal muscles and the thoracic diaphragm are skeletal muscles, precisely the types of muscles that a conducted energy weapon is designed to incapacitate. For this reason, several researchers have investigated whether the current from a conducted energy weapon is capable of interfering with the vital function of these muscles:

- *Jauchem*[202]—six anesthetized pigs were subjected to repeated five-second X26 shocks across the chest, followed by five-second rests, for three minutes. Their respiration rates were monitored, and the researchers reported: "Complete cessation of breathing was noted to occur during each five-second TASER exposure."
- *Ho*[203]—52 human volunteers attending a manufacturer's training program received either a 15-second continuous X26 discharge, or three consecutive five-seconds-on/one-second-off discharges. The electrodes were placed on

202 Jauchem, J.R., et al., "Acidosis, Lactate, Electrolytes, Muscle Enzymes, and Other Factors in the Blood of *Sus scrofa* Following Repeated TASER Exposures," (2005) *For. Sc. Int'l*.

203 Ho, J.D., et al., "Respiratory Effect of Prolonged Electrical Weapon Application on Human Volunteers," (2007) 14 *Acad. Emerg. Med*. 197.

> the subject's trunk in positions to span a majority of the trunk while including transdiaphragmatic positioning. Common placement included ipsilateral and contralateral positioning at shoulder and hip, pectoral region and leg, and scapula and buttock. They found no evidence of breathing impairment during either type of weapon exposure, from which they concluded: "It does not appear that prolonged CEW exposure causes a decreased tidal volume, hypercapnia, hypoxia, or apnea." During his oral presentation, Dr. Ho told me that they actually found that one parameter that they measured (minute ventilation) actually improved, which he interpreted to mean that subjects hyperventilated during weapon exposure in order to blow off excess carbon dioxide caused by acidosis.[204]

These studies are, in my view, inconclusive. While the animal study demonstrated a cessation of breathing during the weapon's discharge, the human study showed just the opposite. The animal study suggests the *capacity* of a conducted energy weapon to disrupt breathing in humans, while one limited human study documented that the breathing of 52 subjects was not interrupted. Would the human study results have been different, for example, if the duration of the weapon discharge had been greater? I am reluctant to generalize from these findings. However, several reports suggest that a link may exist:

- *U.S. Department of Defense*[205]—the Human Effects Center of Excellence conducted a human effectiveness and risk characterization study of the M26 and X26 weapons, during which it identified several unintended effects, including acute respiratory impairment and failure:

  > If long periods of uninterrupted EMI activation did occur, the risk of unintended adverse effects such as … impairment of respiration … could be severe.
  >
  > If placements of the darts induces spasm of the muscles of respiration (diaphragm and intercostal muscles), one can hypothesize that the subject may not be able to breathe. Furthermore, personal

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204 Transcript, May 16, 2008, pp. 13-14. However, it is possible that respiration was inhibited during the 15-second discharge, but that hyperventilation in the 45 seconds after discharge more than made up for the initial respiratory inhibition; *i.e.,* the calculated minute ventilation was improved, but this parameter masked the fact that respiratory inhibition occurred. Dr. Ho also told me about his as-yet-unpublished study in which human volunteers were exposed to a 10-second weapon discharge, in push-stun mode, in the shoulder area. Ultrasound images of the diaphragm showed that in all cases respiration continued; in fact, the diaphragm moved faster during discharge, indicating hyperventilation (pp. 21-22).

205 Maier, A., et al., *Human Effectiveness and Risk Characterization of the Electromuscular Incapacitation Device—A Limited Analysis of the TASER*, by the Joint Non-lethal Weapons Human Effects Center of Excellence," 2004.

> observations during animal studies in pigs … suggest that the test animals hold their breath while being stimulated with the TASER. If humans respond similarly, one would expect no or minimal normal breathing while being exposed. In an extreme case of several minutes exposure during which respiration is impaired, acute respiratory failure, which is immediately life-threatening, could plausibly develop. Acute hypoxia and CO_2 retention cause acidosis, and failure of aerobic cellular production in all tissues with earliest effects seen in the brain and heart.

- *Canadian Police Research Centre*[206]—it stated that "depending on probe location in the upper torso, it appears likely that the muscular tetany produced by a TASER deployment could impair a subject's respiration…. If breathing is stopped or impaired during the five-second cycle, this could affect both CO_2 and pH levels. If the TASER is cycled continuously for 15-20 seconds, the effects could be expected to increase." The authors emphasized that respiratory impairment becomes particularly crucial when the weapon is used or restraint is applied during or after a prolonged physical struggle. They concluded:

> The issue related to multiple CED applications and its impact on respiration, pH levels, and other associated physical effects, offers a plausible theory on the possible connection between deaths, CED use, and people exhibiting the symptoms of ED [excited delirium] (p. 18).

There is another concern associated with interruption or cessation of breathing—acidosis. If the current from a conducted energy weapon interferes with a subject's breathing, that could lead to an increase in the carbon dioxide in the blood, creating carbonic acid, a resulting increase in acidity, and the lowering of the pH level leading to acidosis. As discussed earlier, acidosis can disturb blood electrolytes (such as potassium) and lactate, and can also affect the heart's electrical conduction system, both of which can trigger fatal heart arrhythmias. Acidosis may last for an hour or longer after the initial weapon discharge, which means that the arrhythmia and/or death may be postponed.

One further complication should be noted. As Dr. Ho and others told me, acidosis is cleared primarily by the lungs. Treatment therefore requires stopping further muscle

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206 Manojlovic, D., et al., *Review of Conducted Energy Devices, Technical Report TR-01-2006*, August 22, 2005.

contractions, and restoring oxygen and carbon dioxide exchange. In a hospital setting, providing oxygen is a standard protocol. In the absence of such medical intervention, the body's natural response is to hyperventilate. But hyperventilation can be frustrated if a subject is lying face down (prone), if pressure is applied to the chest or neck area, or if the subject has been restrained or is struggling with police officers who are attempting to restrain the subject. Hence, what would normally be an appropriate police response may in these circumstances prevent the subject's body from clearing acidosis, thereby increasing the risk of cardiac arrhythmias.

D. METABOLIC RISKS

Rhabdomyolysis is muscle damage. It can be brought on by prolonged muscle exertion (*e.g.,* long-distance running, struggling with or fleeing from police), from direct electrical damage to muscles,[207] hyperthermia (*i.e.,* overheating), genetic defects, or ingestion of alcohol or drugs. The primary cause of death in the first 12–24 hours is cardiac arrest from electrolyte (*e.g.,* potassium) imbalances. It also causes the release of muscle breakdown products (*e.g.,* myoglobin, creatine phosphokinase, and potassium) into the bloodstream. If these products are released in levels higher than the kidneys can clear, they can cause acute renal (kidney) failure (usually after 24 hours). Hypocalcemia (low blood calcium) can also occur when high levels of calcium ion leave the blood and flow into damaged muscles, worsening the muscle damage and the acidosis in a vicious cycle.

One of the presenters raised the possibility that a conducted energy weapon could cause rhabdomyolysis. Dr. Butt stated:

> A number of persons who are subjected to the TASER are at risk in the beginning of having hyperthermia or an increased temperature. And one of the

207 In one case a 17 year old who had high-voltage electrical contact with his head was diagnosed with rhabdomyolysis, which led to acute renal failure: Sungur, M., "Rhabdomyolysis Caused by Electric Injury," (2001) 20 *J. Emerg. Med*. 195.

> features pathologically of hyperthermia is disruption, focal disruption of striated or voluntary muscle called rhabdomyolysis.[208]

There is some anecdotal evidence to support this concern. In Alabama, an emergency department physician diagnosed rhabdomyolysis in each of two young men who were admitted after having been subjected to conducted energy weapon discharges.[209] One of the subjects had no prior medical record, but had become severely agitated and began assaulting his mother. He was not intoxicated by alcohol or drugs and, on discharge, was diagnosed with a non-specific psychotic state. The other subject had a history of depression, schizophrenia, ADHD, and marijuana and cocaine abuse. The authors concluded:

> Emergency physicians must consider potential complications and confounding variables as they evaluate patients who have been immobilized by a TASER device. The literature suggests a 1 percent incidence of mild rhabdomyolysis for these patients. Most of these patients will, however, have other conditions or have been involved in scenarios also associated with the development of rhabdomyolysis.

In my view the evidence is inconclusive whether the current from a conducted energy weapon is capable of causing rhabdomyolysis. Having said that, there does appear to be some correlation between a highly agitated (*e.g.,* hyperthermic) subject, the discharge of a conducted energy weapon, and rhabdomyolysis. I will discuss this correlation later in this part.

E. MENTAL ILLNESS

1. Police as first responders

In 2006, the BC Ministry of Health asked the Centre for Applied Research in Mental Health and Addiction (CARMHA) at Simon Fraser University to study the related issues of homelessness, severe addictions, and mental illness. CARMHA found that in British

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208 Transcript, May 21, 2008, p. 7.

209 Sanford, J.M., et al, "Two Patients Subdued with a TASER Device: Cases and Review of Complications," (2008) *J. Emerg. Med*.

Columbia approximately 130,000 adults meet the criteria for severe addiction and/or mental illness. Within that group, an estimated 11,750 are also absolutely homeless.[210]

People with severe addictions and/or mental illness are a disproportionate drain on police resources. In 2007 the Vancouver Police Department collected data over a 16-day period of police incidents that involved a person who was suffering from the effects of a mental illness.[211] Across the city as a whole, 31 percent of all calls for service involved at least one mentally ill person.[212] This amounted to approximately 58,900 out of 190,000 annual calls, for a direct annual cost of $9 million.

Dr. Nancy Hall, a policy consultant with the BC Division of the Canadian Mental Health Association told me that a recent study showed that 30 percent of people accessing the mental health system did so through the police. Ms. Camia Weaver, justice coordinator for the association told me that "police in British Columbia and actually across North America are increasingly first responders to mental health crises, and there is no doubt that they have become the front-line mental health workers in recent years."[213]

From the material that I have reviewed, including video clips of real-life incidents, there can be no dispute that police officers are being called more frequently to deal with subjects whose inappropriate and sometimes violent behaviours suggest mental illness or alcohol/drug incapacitation, or both. When an officer deploys a conducted energy weapon against the subject in such circumstances, the crisis is sometimes resolved. At other times, the subject inexplicably collapses into unconsciousness, and sometimes dies. This scenario, perhaps the most controversial aspect of conducted energy weapon use, is the issue to which I now turn.

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210 Patterson, M., et al., "Housing and Support for Adults with Severe Addictions and/or Mental Illness in British Columbia," Centre for Applied Research in Mental Health and Addiction, Faculty of Health Sciences, Simon Fraser University, February 2008, pp. 8-9.

211 Wilson-Bates, F., "Lost in Transition: How a Lack of Capacity in the Mental Health System is Failing Vancouver's Mentally Ill and Draining Police Resources," January 2008, pp. 12-13.

212 This level rose to nearly 50 percent in District 2, which includes the Downtown Eastside.

213 Transcript, May 7, 2008, p. 19.

To put into context the discussion that follows, it would be useful to list the cluster of physical symptoms and behaviours that police officers frequently encounter, as set out in the manufacturer's training materials:

- bizarre or violent behavior;
- signs of overheating/profuse sweating;
- disrobing;
- violence toward/attacking glass, lights, and reflective surfaces;
- superhuman strength and endurance;
- imperviousness to pain—self-mutilation;
- disturbances in breathing patterns or loss of consciousness; and
- complaints of respiratory difficulty.[214]

2. What psychiatrists and other medical experts told me

I am indebted to several psychiatrists and other medical experts who greatly enhanced my understanding of mental illness, specifically delirium. I summarize their oral presentations below.

a. Dr. Shaohua Lu

Dr. Lu is a psychiatrist at the Vancouver General Hospital's medical surgical unit. He assesses, on a daily basis, patients with severe addictions and severe mental illnesses such as schizophrenia, bipolar disorder, and delirium, and has seven years' previous experience in an emergency psychiatry unit.

Dr. Lu told me that the *Diagnostic and Statistical Manual, Volume IV* (DSM-IV) defines delirium as a disturbance of the conscious mind, with reduced ability to focus or sustain attention. It involves a change in cognition, or the development of a perceptual disturbance that is not better accounted for by a pre-existing dementia. The disturbance develops over a short time, and tends to fluctuate during the course of the day.

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214 TASER International, "User Certification Course * TASER X26 Electronic Control Device," Version 14.0, PowerPoint presentation, slide 196.

If delirium can be broadly defined as a generalized cognitive and brain dysfunction, it presents itself as follows:

- *Impaired level of consciousness*—the person will present as drowsy or agitated, typically with a disrupted sleep-wake cycle.
- *Attention deficits*—the person will be disoriented, not knowing what time it is or, in more severe cases, who they are. They will have poor attention and concentration, experiencing difficulty following basic instructions.
- *Language deficits*—the person will have impaired comprehension and speech, with difficulty in articulating their thoughts, which may cause them to appear more aggressive than normal.
- *Memory deficits*—the person may have impaired short-term memory and working memory, and experience difficulty answering questions about where they are and what they are doing.
- *Executive cognition function impairments*—there is a generalized disorganization and impaired insight (meaning that they do not have an appreciation that they are in a disorganized state), with a decreased ability to plan, organize, and execute tasks.
- *Thought disturbances*—the person will often have delusional thinking and illogical thought processes, such as thinking they are being abducted or, in the case of older patients, thinking they are still fighting World War II. This can lead to bizarre behaviours.
- *Disturbed effects*—most patients with delusions are in an unstable state—scared, frightened, and in a state of anxiety and irritability.
- *Perceptual disturbances*—the person may misinterpret external and internal stimuli and, depending on severity, may experience visual, auditory, or tactile hallucinations.
- *Psychomotor changes*—the person typically experiences agitation and restlessness, which can have a profound impact on their strength. Even elderly patients can display tremendous strength. This "defensive aggression" is rarely directed at any specific individual and is not meant to harm anyone. Rather, the person is just frightened, and may barricade himself or herself, or throw things as a reaction to what they perceive as an intrusion into their personal space.
- *Autonomic instability*—delirium is a medical, physiological response to external insults (*i.e.,* changes in perception), and patients will almost always exhibit autonomic instability, including rapid breathing, sweating, increased heart rate, and unstable blood pressure.

Dr. Lu told me that psychiatrists do not use the term "excited delirium." In their understanding, most patients with delirium are in an excited and agitated state. Those who use the term "excited delirium" appear to be describing a patient who has delirium with a highly agitated and extremely restless presentation—"the more severe spectrum of delirious presentation."

Dr. Lu emphasized that delirium is not a medical disease. It is a syndrome, and it is a symptom of many underlying problems. He then listed the principal predisposing and risk factors: advanced age, dementia, medical co-morbidity, a history of alcohol abuse, male gender, sensory impairments (especially hearing and vision), unfamiliar settings, language barrier, and dehydration.

There are also numerous precipitating factors that can put the person over the edge and generate a delirious state, including environmental change, pain, emotional stress or social isolation, prolonged sleep deprivation (including long-haul flights), prolonged sensory deprivation or stimulation, metabolic disturbance (*e.g.,* dehydration or electrolyte changes), neurological conditions (*e.g.,* stroke or head injury), surgery, severe medical illness or trauma, exposure to anesthetics, infections, hypoxia (shortage of oxygen), fever, hypothermia, or drugs and medications. A simple dose of morphine for pain, or heroin, can bring on delirium. Cocaine and psycho-stimulants are highly precipitating agents for delirium, as is acute alcohol or sedative withdrawal.

Dr. Lu added that "the more vulnerable the individual, the less noxious insult is necessary to precipitate delirium. The healthier the individual, the more trauma and more medical problems are necessary to get into that state."

Cocaine (and other psycho-stimulants such as crystal methamphetamine) has a direct stimulation effect on the cardiac function, particularly in new users. It will increase the heart rate and the demand for oxygen, and it can potentially disrupt the rhythm of the heart. In combination with low doses of alcohol, cocaine can also form additional compounds that stimulate the speed of the heart.

It is often difficult, even for psychiatrists, to determine whether a patient is in a delirious state, as opposed to extreme depression or psychosis. In extreme cases, delirium is a medical emergency. In otherwise healthy individuals, sudden onset of delirium may be a warning sign of potentially life-threatening metabolic changes or extreme fatigue and exhaustion, which can lead to cardiac arrest and sudden death.

Dr. Lu told me that in a hospital setting, professionals use a variety of techniques to manage delirium. They will use social restraint (which may mean placing the patient in a comfortable, familiar setting), reduce stimulation, bring in a family member or friend, or find someone who speaks the patient's language. In cases of dehydration, they will rehydrate the patient. They will normalize the patient's sleep, and attempt to correct the underlying medical problem. If it is necessary to physically restrain a highly agitated patient, they will initiate pharmacological treatment (*e.g.,* benzodiazepine or an antipsychotic drug) as soon as possible to reduce agitation.

Dr. Lu offered practical suggestions for first responders who must deal with delirious subjects:

- *Education, training, and recognition*—it may not be particularly helpful to attempt to determine whether the subject's delirious state is due to cocaine or methamphetamine ingestion, psychosis, extreme psychosis as a result of untreated schizophrenia, or severe bipolar. Rather, it is important that a first responder recognize that a delirious patient can have autonomic changes such as sweat, disorganization, disorientation, and defensive aggression. They should recognize that patients are frightened and may not be capable of following basic instructions, and they should receive training on how to talk to patients and calm them down.
- *Use containment whenever possible*—this means keeping the subject in a prescribed area (but not physically restraining them) in order to buy time to bring in familiar support.
- *Medical/paramedic backup*—this should be brought in as soon as possible if it appears that a subject is in a delirious state.
- *Restraints and conducted energy weapons*—first responders should be aware of the medical risks associated with physically restraining a delirious subject, or deploying a conducted energy weapon against them. In the case of an otherwise healthy individual, they likely have profound exhaustion and electrolyte changes before delirium kicks in. At that stage, any additional

insult (*e.g.,* struggling or fighting) can lead to the body just giving out, resulting in cardiac arrest and death.

- *Monitor basic vital signs*—monitor the heart rate, breathing rate, and level of consciousness.
- *Severe agitated delirious state*—if medical/paramedic backup is present, then sedation, oxygen, IV fluids, and a low-stimuli environment should be considered. Cooling measures are particularly helpful for young males whose delirium is caused by cocaine or crystal methamphetamine or other drug-induced agitated state.

b. Dr. Joseph Noone

Dr. Noone is a psychiatrist at the Riverview Hospital in Coquitlam, BC, serving as the medical director of the Adult Program and medical manager of the Psychiatric Intensive Care Unit. He is a clinical professor of psychiatry at the University of British Columbia, and provides on-call emergency psychiatric services in the emergency departments of three Lower Mainland hospitals. He is also a director of Code White training, which focuses on team interventions with higher levels of aggression. The main focus of his clinical practice for the past 27 years has been the prevention and management of aggressive behavior in healthcare.

Dr. Noone told me that delirium is an acute confusional state with fluctuating levels of consciousness. There is usually hyperactivity, but occasionally lethargy. There is a rapid succession of confused, unconnected ideas, often with illusions (visual misperceptions) and hallucinations. Delirium is most frequently caused by drugs, a closed-head injury, hypoglycemia, electrolyte disturbance, or an acute psychosis such as schizophrenia or manic or bipolar mood disorder.

He emphasized that advanced delirium is a medical emergency, not a psychiatric emergency, requiring intensive medical assessment and management. The goal of treatment is to reverse the causes.

Dr. Noone said that “excited delirium” is not a valid medical or psychiatric diagnosis. In his view it provides a convenient post-mortem explanation for in-custody deaths, where physical and mechanical restraints and conducted energy weapons were employed. His main concern about usage of this term is that “it’s being used more and more frequently in an attempt to automatically absolve law enforcement from any and all responsibility for their involvement in sudden in-custody deaths."[215] It would be preferable to:

- avoid use of the term "excited delirium" (which implies a diagnosis), and use the more descriptive, less judgmental term of "emotionally disturbed person"; and
- focus on the principal risk factors for in-custody death—positional asphyxia, cocaine-induced psychosis or delirium, and neuroleptic malignant syndrome.

Dr. Noone said that the best way to treat an emotionally acting-out person is to do the following:

- *Assess*—you should approach the situation objectively and with an open mind, considering all the possibilities. You should take your time and remain calm. If the degree of force used by the professional is measured on a scale of one to ten, police officers often go in at eight or nine, and this will likely escalate rather than defuse the situation. From his experience, it is much more effective to go in at about three or four—if you go in low, you can usually get compliance.
- *Contain*—it is unwise for one, two, or even three people to attempt to contain a highly agitated subject. From Dr. Noone's experience, a team response is much more effective. Instead of grabbing the subject roughly, "gentle touching, not touching, showing support is what will bring this confused person down to a level where you can deal with them."
- *Treat*—once the subject has been transported to the emergency department, it is important to treat the subject for the underlying medical condition. Delirium is a superimposed condition for which there are medical reasons. Often this type of aberrant behaviour is not psychotic—"The big mistake we don't want to make is to treat something as behavioural when in fact it has a medical cause."

When asked about the appropriateness of deploying a conducted energy weapon against a person in a delirious state, Dr. Noone replied:

> I believe that highly agitated individuals, even more so if they are in delirium, are at very high risk of further medical compromise, due to metabolic, cardiac, respiratory, or other complications. To "taser" such vulnerable individuals

215 Transcript, May 16, 2008, p. 41.

> would be contraindicated medically due to the risk of death, in my opinion. That's a clinical opinion.[216]

Dr. Noone referred to two paragraphs of the RCMP Operational Manual[217] that until February 2009 stated:

> 3.2.2. Individuals experiencing excited delirium require medical treatment which first requires that they be restrained.
>
> 3.2.3. In considering intervention options for excited delirium cases, the use of the [conducted energy weapon] in a probe-mode deployment may be the most effective response to establish control.

He disagreed with that policy for several reasons. First, "excited delirium" is not a medical or psychiatric condition, and use of the expression in the manual could refer to just about anything. Second, medically untrained people (including police officers) may apply this policy to any agitated individual, whether delirious or not, which would be a worrisome development. Third, use of a conducted energy weapon on a small number of highly agitated individuals who are really in delirium is strongly medically contraindicated. The safest and most effective method of restraint and transportation would be a trained team intervention using soft empty-hand control, while working to maintain a relationship with the individual.

He said that the healthcare approach to prevention and management of aggressive behavior is respect and professionalism, not power and control, which only causes conflict and incites the situation. When control is required, it is important that it be applied in a supportive, respectful manner. Communication is very important, including body language, facial expression, managing the distance, speed of movement, and the volume, tone, rate, and rhythm of speech. He has found that in the vast majority of emotionally disturbed, mentally ill and alcohol/drug-intoxicated people, the use of presence, dialogue, and empty-hand control measures achieve compliance, without resort to pain compliance or closed-fist responses or impact weapons.

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216 Transcript, May 16, 2008, p. 49.

217 RCMP Operational Manual—Chapter 17.7—Conducted Energy Weapon.

c. Dr. Maelor Vallance

Dr. Vallance is currently clinical emeritus professor of psychiatry at the University of British Columbia. He has practised psychiatry for more than 40 years, including administratively as chair of the Forensic Commission and clinically as director of emergency psychiatric services at Vancouver General Hospital.

Dr. Vallance told me that the principal features of delirium are a reduced clarity of awareness of the environment or clouding of consciousness that leads to considerable impairment of attention. Anything coming from the outside, including instructions from the police, may not get through. Even if they do get through, they may not be held in consciousness long enough for the individual to act on them.

There are also changes in cognition, such as disorientation (especially for time), impairments of memory (so that warnings may be quite useless), and problems understanding and expressing language. There may be perceptual disturbances, such as illusions and hallucinations, where they will misinterpret what they hear or see.

Delirium fluctuates. It is usually worse at night because there is less orienting stimulation to keep them on track. It also varies with the level of excitement—the greater the excitement, usually, the greater the derangement.

Dr. Vallance said that there are many underlying causes of delirium, including a general medical condition (*e.g.,* liver disease, AIDS, gross dehydration, electrolyte disturbances or imbalance, acidosis), drug intoxication (especially cocaine and crystal methamphetamines), alcohol withdrawal (*e.g.,* delirium tremens), or a combination of factors (*e.g.,* someone with AIDS who also has cocaine intoxication, or someone with pneumonia who has an aberrant reaction to a medication).

It is not always easy to differentiate delirium from other conditions (*e.g.,* excited catatonic schizophrenia, mania, or agitated dementia), particularly in the community and especially when the person is severely agitated. Observation alone is insufficient for diagnosis; interactions with the individual and collateral data are also required.

Police officers may observe agitation or derangement, but would have no way of knowing the specific condition with which they are dealing.

Dr. Vallance told me that "excited delirium" is not a medical term. It is not described in the medical literature, nor is there real clinical evidence of it as a separate entity. There is no specific pathology post-mortem. He said:

> The symptoms and the behaviours that you see in what is called "excited delirium" are essentially indistinguishable from a deranged, agitated individual in the community, irrespective of the underlying cause. And there is no known specific pathology. In short, there's nothing to identify it.
>
> The features as they are described of excited delirium … are essentially the features that you would find in any severely agitated, deranged individual, whether they are suffering from a true delirium with all of its underlying medical causes, a severely agitated schizophrenic, or a severely agitated manic patient; there's nothing to differentiate it from these conditions.[218]

Dr. Vallance said that deaths do occur in temporal proximity to various interventions, which may include a conducted energy weapon, forceful physical restraint, chokeholds, or pepper spray. This occurs mostly in those individuals who are the most physically compromised in our community, such as those with a serious medical condition, poor nutrition, serious dehydration, or cocaine intoxication. Also, their level of exhaustion is an extremely important factor. One would expect that as exhaustion approaches there would be a gradual slowing down of activity and a lessening of resistance. However, just the opposite occurs. It is like a car with the gas pedal fully down. It will go at full speed until it runs out of gas. If such people are subjected to a conducted energy weapon when they are "running out of gas," it is analogous to someone pressing down on the brake pedal while the gas pedal is still fully down—the car spins out of control. It is when such highly agitated people are physically restrained and then collapse into inactivity that they are most vulnerable. He said:

218 Transcript, May 21, 2008, p. 21.

> We need to have protocols for intervention, particularly using [conducted energy weapons] because we know relatively little about them. When should they be used and when should they not be used? …
>
> The first step in intervention should very rarely be physical restraint of any kind. The physical restraint by itself tends to escalate the situation, when the purpose really should be to de-escalate. The escalation of the situation with further agitation and excitement is a danger in itself.
>
> In order to intervene without using physical restraint as a first step, I believe it's necessary to develop specialized intervention teams. There is specific training in that form of intervention. I believe that it's too much to ask the police force to have the level of training that is available as a general training throughout the police. It requires specific selected officers to be specifically trained under our very extensive training programs now. Even then, I don't believe that they should act alone. I believe it should be a team effort.[219]

d. Dr. John Butt

Dr. Butt is a forensic pathologist in Vancouver, BC. In the 1970s, he was instrumental in the reform that converted Alberta's coroner system into a medical examiner system. He served as Chief Medical Examiner in Alberta for 16 years and as Chief Medical Examiner in Nova Scotia for three years. In 1990, he served as president of the National Association of Medical Examiners in the U.S.A. In 2004, he and several colleagues provided medical expertise to the Victoria Police Department's report on conducted energy weapons.

Dr. Butt told me that the principal role of a coroner or chief medical examiner is to determine the medical cause of death. If, on autopsy, there is no pathology present explaining the death, then the circumstances surrounding the death become very important. This is relevant in deaths proximate to use of a conducted energy weapon, because there is no specific pathology related to the use of such weapons. For example, the electrical current from a weapon is not sufficient to leave burn marks (in contrast to electrocution from power lines), and even if the weapon caused a heart arrhythmia, that would not be evident on autopsy.

219 Transcript, May 21, 2008, p. 24.

In such "negative autopsy" cases, studying the proximate events is essential to developing an understanding of the mechanism of death. This is particularly true when dealing with emotionally disturbed subjects, many of whom display hyperactivity, agitation, hyperthermia, feats of strength, numbness to pain, and a disposition to resist force. Dr. Butt said that researchers were aware of sudden in-custody deaths long before conducted energy weapons were introduced, and several explanations were proposed, including asphyxia (due to kneeling on the subject's trunk or neck and thus restricting breathing) and metabolic acidosis (due to sudden changes to the acid level of the blood brought on by a struggle or other convulsive muscle movement). Pathologists sometimes do not understand how these mechanisms may have contributed to a death, and may assign death to "sudden death associated with custodial death syndrome" or "sudden death associated with excited delirium (custody)" without going behind the symptoms to find the underlying anatomical cause of death.

Dr. Butt spoke in favour of involving mental health professionals (in addition to paramedics) when dealing with emotionally disturbed subjects, because of their skills in de-escalating tense situations—cooling off—"puts the situation into a much safer mode for everybody."

e. Dr. Christine Hall

Dr. Hall is a specialist in emergency medicine in Victoria, BC. She also has a master's degree in epidemiology. Her interest in conducted energy weapons arose from her experience with a surprising number of emergency patients who are acutely agitated, disruptive, violent, and incoherent; who become involved in profoundly intense physical interaction with the police; and who, when finally physically controlled in some way, sometimes die unexpectedly within minutes.

Her review of the literature showed that such in-custody deaths pre-date introduction of conducted energy weapons, and early attempts to explain such deaths were unpersuasive. Her particular professional interest is what to tell police officers to do when they encounter an agitated and incoherent person. She offered three suggestions:

- *Recognize the medical emergency*—although the acutely agitated violent person may be engaged in behaviour that manifests as a police problem, the person may well be a medical emergency.
- *Facilitate medical treatment*—the person needs to get to a hospital; in urban areas an ambulance crew with advanced life support skills may be able to medicate the person with a sedative once the person is under some physical control.
- *Getting control of the person*—the problem is that there is no simple way to give care to a violent, combative, and incoherent person without first getting control over them. The ideal response is to contain the situation until medical backup arrives, but it is not always possible for the police to stand by if people are at physical risk or property is being destroyed.

f. Dr. Michael Webster

Dr. Webster has a doctorate in counselling psychology. He initially practised in several federal penitentiaries in British Columbia, but subsequently developed an expertise in crisis situations, hostage-takings, barricaded person incidents, kidnappings, and incidents of public disorder. He now provides consulting services to policing bodies in Canada and internationally.

Dr. Webster agreed with other presenters that police patrol personnel are often faced with individuals exhibiting bizarre and/or aggressive behaviours, shouting, elevated suspicion, anxiety or panic, violence, unexpected physical strength, and profuse sweating. He expressed the following concern:

> Even with an extensive autopsy, there is no definitive way to prove that someone died of excited delirium. It may be that police and medical examiners are using the term as a convenient excuse for what could be excessive use of force or inappropriate control techniques during an arrest.

He told me that properly trained mental health professionals are aware that the more active variety of delirium increases the risks associated with physical restraints. He said that most mental health professionals would agree that people manifesting this symptom picture are in a state of hyperarousal and are in crisis.

Crisis intervention is designed to assist people in lowering their arousal level and regaining their mental balance, enabling them to use better judgment, make decisions, and become better problem solvers. The method most amenable to police first responders is the creation of a safe, non-threatening environment. In his words, "The first rule of crisis intervention is: no more crisis." As a police psychologist, Dr. Webster said that from a review of conducted energy weapon tragedies, it is not difficult to see numerous violations of this rule.

He recommended that Canadian law enforcement recruits be provided with crisis intervention training during their basic police training, which usually entails

> five to seven days and covers a broad array of topics, including drug awareness, mental health issues, conflict and crisis theory, crisis intervention, verbal and non-verbal communication techniques, and experiential exercises.

g. Canadian Mental Health Association, BC Division

Camia Weaver, a lawyer who serves as justice coordinator for the BC Division of the Canadian Mental Health Association, told me that in 2003 the association published *A Study in Blue and Grey*, dealing with issues and solutions to interactions between police and people with mental illness. It outlines the best practices in police interventions and has become a primary resource for the development of comprehensive programs of police response to persons with mental illness.

In 2005, the association started a Mental Health and Police project, a collaborative process between police, mental health professionals, consumers, and family members. It mapped the first response to people with mental illness in the community, the gaps in that response, and developed action plans. In 2006, that project was expanded from the original six communities to nine communities.

The association strongly believes that there should be standardized and improved crisis intervention training for dealing with people with a mental illness. There is very little such training at the Justice Institute for police recruits and, according to Ms. Weaver, "There is a philosophical difference, almost an opposition, between the typical police training, which is command and control, and the tenets of effective crisis intervention communication techniques." Rather than relying on a designated police cruiser with a psychiatric nurse accompanying the officer (such as Car 87 in Vancouver and Car 67 in Surrey), best practices suggest that:

> [T]he key components for the most effective crisis response include a core of carefully selected, first-call crisis response officers who are available in all districts 24 hours a day, seven days a week [with] specialized dispatch because a number of the issues that come up in terms of crisis response have to do with the ability for a dispatcher to accurately assess and obtain and provide the information needed for an effective response.

Interactions with mentally disordered persons are less likely to become combative when a de-escalating communication approach is used instead of a command and control approach. This type of crisis intervention team approach has already been implemented in numerous cities, including Memphis, Portland, and Seattle. Ms. Weaver told me that research data confirms the benefits of using crisis intervention team models to reduce injury and death (to the mentally ill and to the police) and to increase more appropriate outcomes to police interventions.

Ms. Weaver said that when the police first began using conducted energy weapons in British Columbia in 1999, the BC Division of the association endorsed their use as a less lethal alternative to deadly force. While the BC Division continues to endorse their use as a preferred alternative to lethal force options, it is concerned about the weapon's placement as an intermediate weapon on the use-of-force continuum, which means that it is authorized for use at the early stage of active resistance. The division strongly recommends that conducted energy weapons be used only as an alternative to deadly force when all other options are exhausted.

She added that "excited delirium" is not a recognized medical condition, but rather a term used to describe a cluster of symptoms which have not been clearly attributed to any specific cause. When this cluster of symptoms is present, there is an increased potential for death. Consequently, policies surrounding conducted energy weapon use should require that medical personnel be called on an emergency basis before or as soon as possible after the weapon is used, when these symptoms are present. If it is a worst-case scenario where all other methods of crisis intervention have not de-escalated the situation and a conducted energy weapon is used as a last resort, it is essential that officers be ready to move in and restrain the subject after only one weapon discharge, and that emergency medical personnel be standing by, ready to move in without delay.

3. Conclusions

From this review, I have reached several conclusions.

First, police officers are called upon, with increasing regularity, to deal with emotionally disturbed people who display extreme behaviours, including violence, imperviousness to pain, superhuman strength and endurance, hyperthermia, sweating, and perceptual disturbances.

Second, such emotionally disturbed people are often at an impaired level of consciousness; may not know who they are or where they are; may be delusional, anxious, or frightened; and may be unable to process or comply with an officer's commands.

Third, this cluster of behaviours is not a medical condition or a diagnosis. Rather, the behaviours are more accurately understood as symptoms of a variety of underlying medical conditions that, in extreme cases, may constitute a medical emergency. For example, the subject's extreme fatigue or exhaustion, or metabolic changes, may lead to cardiac arrest. Similarly, cocaine intoxication may stimulate the heart, leading to deadly arrhythmias.

Fourth, a police officer encountering an emotionally disturbed person is not trained to make a medical diagnosis, and it is, in any event, not appropriate to do so. The officer's challenge is how to deal with the observable behaviours, whatever the underlying cause. It is, in my view, not helpful to characterize people displaying these behaviours as suffering from "excited delirium."[220] Doing so implies that "excited

220 As of February 2009 the RCMP's Operational Manual no longer uses the term "excited delirium."

delirium" is a medical condition or diagnosis, when mental health professionals uniformly reject that suggestion. To the contrary, I am satisfied from the oral presentations of several psychiatrists, that the behaviours observed by police officers are entirely consistent with an extreme form of delirium, which is a recognized cognitive and brain dysfunction, a symptom of an underlying medical condition.

Fifth, it is equally troubling to hear, after a death proximate to conducted energy weapon use, that it was not the weapon that caused the death, but "excited delirium." The danger with that line of reasoning is that the clusters of extreme behaviours observed by the police did not cause the death any more than extreme pain causes the death of a burn victim. Assigning responsibility to such symptoms (in the guise of a diagnosis) conveniently avoids having to examine the underlying medical condition or conditions that actually caused death, let alone examining whether use of the conducted energy weapon and/or subsequent measures to physically restrain the subject contributed to those causes of death.

Sixth, the real challenge facing the policing community, and our policy-makers, is determining how police officers should respond to such emotionally disturbed people. The unanimous view of mental health presenters was that the best practice is to de-escalate the agitation, which can best be achieved through the application of recognized crisis intervention techniques. Conversely, the worst possible response is to aggravate or escalate the crisis, such as by deploying a conducted energy weapon and/or using force to physically restrain the subject. I was impressed with how effective these crisis intervention techniques are, and how routinely mental health professionals use them. It seems clear that the "command and control" philosophy underlying police recruit training, however appropriate generally, is both inappropriate and counterproductive when dealing with emotionally disturbed people.

Seventh, even mental health professionals acknowledge that there may be some extreme circumstances, however rare, when crisis intervention techniques will not be effective in de-escalating the crisis. In such cases, the ultimate goal must be to get initial medical treatment (*e.g.,* sedation) to the agitated subject. For that to happen, it may be necessary to physically restrain the subject and, for that to happen, it may be necessary (depending on the factual circumstances) to deploy a conducted energy weapon. When that happens, best practices indicate that the weapon should be deployed for the shortest time possible, officers should immediately move in to restrain the subject, and medical first responders should initiate treatment immediately following restraint.

F. SUBJECTS WITH OTHER VULNERABILITIES

1. Young and/or physically small subjects

Although there is an understandable aversion to using a conducted energy weapon against a young person, I am not aware of any evidence indicating that young age by itself poses a higher medical risk.

Having said that, some of the animal studies discussed earlier show a correlation between skin-to-heart distance and risk of ventricular fibrillation—as the distance between the skin and heart decreases, the risk of ventricular fibrillation increases. It would not be unreasonable to infer from such data that when a conducted energy weapon is deployed across the chest of an unusually thin subject, there is an increased risk that the weapon's electrical current may cause a heart arrhythmia, which could lead to ventricular tachycardia and/or ventricular fibrillation.

It is not unusual for some teens to be thinner than adults while their bodies are experiencing rapid growth. It is, therefore, reasonable to assume that they may be more vulnerable to these medical consequences, if subjected to conducted energy weapon deployment across their chest. However, based on the information before me, it is their thinness, not their youth, that makes them more vulnerable. Indeed, the "thinness" concern would logically apply regardless of age. It is my understanding that *commodio cortis* is exclusively seen in adolescent children (predominantly boys) who play baseball or hockey. It has been postulated that the thin chest wall and small skin-to-heart distance typical of such children places them at particular risk for mechanical trauma on the T-wave, causing ventricular fibrillation.

2. Elderly subjects

The evidence indicates that elderly subjects are at greater risk if a conducted energy weapon is used against them. This increased risk arises from greater likelihood that elderly people will have underlying medical conditions, which make them more vulnerable. For example:

- Dr. Lu told me that elderly people have an increased susceptibility to delirium.
- Mr. Reilly told me that elderly people have a greater incidence of orthopedic (bone) frailties. Strong muscle contractions triggered by conducted energy weapon deployment could cause compression fractures, or falling due to muscle incapacitation could cause limb or hip fractures.
- Several cardiologists told me that people with cardiovascular disease are at a significantly higher risk of ventricular fibrillation.

3. Pregnant women

Several concerns have been expressed about deploying a conducted energy weapon against a pregnant woman. For example, deploying the weapon in probe mode across the woman's abdomen might trigger muscular spasms that could induce labour, or the electrical current from the barbs might reach the fetus and trigger an arrhythmia. While both scenarios appear plausible and several anecdotal accounts suggest a relationship,[221] I am not aware of any research substantiating those concerns.

A related concern arises from the fact that deployment of a conducted energy weapon in probe mode causes incapacitation and falling to the ground without the subject having the ability to break the fall. This could pose a particular risk for pregnant women.

221 See Amnesty International, '*Less than lethal?' The Use of Stun Weapons in US Law Enforcement*, (2008), p. 91, available at http://www.amnesty.org/en/library/asset/ AMR51/010/2008/en/65fd4233-cb63-11dd-9ec2-e57da9519f8c/amr510102008en.pdf.

G. RISKS ASSOCIATED WITH HOW THE WEAPON IS USED

1. External circumstances

It is not in dispute that deployment of a conducted energy weapon in several particular external circumstances will increase the risk of injury to the subject or to others nearby. Deployment in probe mode incapacitates the subject, so the following high-risk situations have been identified:

- *Heights*—when the subject is more than a few feet above the ground (*e.g.,* on a ladder or roof) and will, if incapacitated, fall to the ground.
- *Water*—when the subject is in a body of water that is deep enough so that, if the subject falls into it while incapacitated, the subject may drown.
- *Driving or operating machinery*—a subject driving a vehicle or operating machinery will lose control when incapacitated, which could cause injury to the subject or other people in the vicinity.

There is also a risk that the sparking of a conducted energy weapon could ignite flammable liquids or gases, such as gasoline, natural gas, or gases found in sewer lines or methamphetamine labs, or in self-defence sprays that use flammable carriers such as alcohol. Even some formulations of oleoresin capsicum (pepper) spray used by police officers are flammable.

2. Mode of deployment

a. Push-stun mode

When a conducted energy weapon is used in push-stun mode, the muzzle of the weapon is pressed against the subject's skin. When the trigger is pulled, an electrical current jumps between the two electrodes mounted on opposite sides of the muzzle, sending the current into the subject's skin. Because the electrodes are less than five centimetres apart, the current does not penetrate deeply enough into the subject's body to cause neuromuscular incapacitation.

Everyone agrees that the current is very painful, and often has the desired effect of persuading the subject to let go of a railing or otherwise achieving compliance through intense pain.

Because the weapon does not cause incapacitation when used in push-stun mode, there is little risk of fall-related injuries. However, the manufacturer trains to use caution when applying the weapon to the neck or groin area, because these areas are sensitive to mechanical injury, such as crushing the trachea or testicles if the weapon is applied forcefully.

b. Probe mode

As discussed earlier in this part, there are significantly greater medical risks when a conducted energy weapon is used in probe mode, including:

- ventricular tachycardia and/or ventricular fibrillation;
- myocardial infarction;
- rupture of a pre-existing aneurysm or heart wall;
- acute stroke;
- impairment of respiration, which could lead to acidosis; and
- rhabdomyolysis (muscle damage) that could lead to cardiac arrest or acute renal (kidney) failure.

In addition, several presenters cited examples of compressive fractures caused by severe muscle contractions, limb and hip fractures caused by falling, and injuries to internal organs (*e.g.,* lung and brain) or to eyes and genitals from probe penetration.

The *Canadian Medical Association Journal* recently reported a case[222] of a healthy police officer being accidentally hit by a conducted energy weapon deployed in probe mode—one barb in his upper back and the other in the occiput (back part of head). His colleague found him unresponsive and foaming at the mouth. His eyes were rolled upward and he had generalized tonic-clonic movement (*i.e.,* a generalized seizure affecting the entire brain) with apnea lasting for about one minute. He was confused

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222 Bui, E.T., Sourkes M, and Wennberg, R., "Generalized Tonic-Clonic Seizure after a Taser Shot to the Head," *CMAJ* March 17, 2008; 180(6).

and combative in the postictal period. On the Glasgow Coma Scale (three being the worst and 15 the best), he scored nine within five minutes, increasing to 13 five minutes later. He returned to work five days later, but experienced persistent headaches, dizziness, back pain, and chest tightness. He was diagnosed with mild traumatic brain injury (concussion), in addition to provoked seizure. A psychiatric consultation seven months after the injury suggested an Axis I diagnosis of adjustment disorder with depressed and anxious mood. The authors stated, "The taser current that passed to his brain from the dart in the occiput probably provoked the seizure directly, with a mechanism akin to that of seizures induced by electroconvulsive therapy…. It is plausible that a copper dart penetrating the scalp and discharging 95 pulses of 100 micro-coulombs each could trigger a generalized convulsion."

3. Repetitive deployment

There are several ways in which a conducted energy weapon can be deployed repetitively:

- When used in push-stun mode, the weapon will discharge an electrical current for five seconds, and that cycle can be repeated with each subsequent pull of the trigger.
- When used in probe mode, the weapon will initially discharge an electrical current for five seconds, and that cycle can be repeated with each subsequent pull of the trigger.
- After a weapon has been deployed in probe mode, the cartridge can be removed, and the weapon can be used in push-stun mode.
- Two or more weapons can be deployed against the same subject simultaneously, in either push-stun or probe mode.

The Commission's empirical study of conducted energy weapon use in British Columbia revealed that when used in push-stun mode, the subject was exposed to only one push-stun deployment in 55 percent of cases, and two such deployments in 26 percent of cases. The most push-stun deployments experienced by a subject was 14.

When used in probe mode, the weapon was deployed for one cycle in 64 percent of cases, and for two cycles in 22 percent of cases. The most probe mode cycles deployed against one subject was 10.

In approximately 7 percent of cases, a conducted energy weapon was deployed in both push-stun and probe mode, and the frequency of such dual deployments has more than doubled since 2000.

Logic would suggest that if a single discharge of a conducted energy weapon, especially in probe mode, creates a medical risk, then repetitive deployments against one subject would increase that risk. Dr. John Webster, a biomedical engineer, told me that animal studies have shown that repetitive deployments increase the risk of ventricular fibrillation, and these results satisfy him that "there's no doubt that multiple tasering is more dangerous than single taserings."[223]

With respect to respiration, it has been suggested that involuntary contraction of respiratory muscles, such as the diaphragm and intercostal muscles surrounding the rib cage, may impair respiration. In 2005, the BC Police Complaint Commissioner stated in his *TASER Technology Review—Final Report*:[224]

> The effect that TASER application has on respiration remains an area of concern. Muscular tetany that impairs respiration may be an operative factor that has been previously unrecognized. This concern also relates to the issue of multiple usages.

There is also a concern that the combination of impaired respiration and muscular contraction can, in multiple deployments of the weapon, increase the risk of acidosis. The authors of the Canadian Police Research Centre's 2005 *Review of Conducted Energy Devices* examined the evidence of respiratory impairment and pH changes resulting from multiple applications of conducted energy weapons, and concluded that:

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223 Transcript, May 5, 2008, p. 78.

224 OPCC File No. 2474, June 14, 2005, p. 12.

> Training protocols, however, should reflect that multiple applications, particularly continuous cycling of the TASER for periods exceeding 15-20 seconds, may increase the risk to the subject and should be avoided where practical.[225]

Until April 2008, the manufacturer acknowledged in its training materials an increased risk of impaired respiration from multiple deployments. For example, Version 12 (November 2004) and Version 13 (May 2006) of its training materials stated:

> TASER applications directly across the chest may cause sufficient muscle contractions to impair normal breathing patterns. While this is not a significant concern for short (5 sec) exposure, it may be a more relevant concern for extended duration applications.

Also, in a June 2005 Training Bulletin, the manufacturer cautioned:[226]

> Repeated, prolonged, and/or continuous exposure(s) to the TASER electrical discharge may cause strong muscle contractions that may impair breathing and respiration, particularly when the probes are placed across the chest or diaphragm. Users should avoid prolonged, extended, uninterrupted discharges or extensive multiple discharges whenever practicable in order to minimize the potential for over-exertion of the subject or potential impairment of full ability to breathe over a protracted time period.

However, the manufacturer's more recent publications reflect a significant change in position:

- Version 14 of its training materials state, "Tests show that there are no adverse effects on heart function or respiration deriving from multiple or prolonged deployments."
- An April 2008 Training Bulletin states:[227]

225 Technical Report TR-01-2006, p. 15.

226 TASER International, Inc., Training Bulletin 12.0-04, *TASER Law Enforcement Warnings*, Release date June 28, 2005.

227 TASER International, Inc., Training Bulletin 14.0-03, *TASER Law Enforcement Warnings*, Release date April 28, 2008. See http://www.taser.com/training/Documents/Training%20Bulletin%2014-03.pdf.

> The available human data directly contradicts prior animal studies and does not reveal any evidence of breathing impairment or respiratory acidosis….
>
> While prolonged muscle activity does produce lactic acid, human studies of ECD exposures up to 15 seconds (or 3 cycles) have shown that there is no evidence of metabolic acidosis.

In related reference sheets,[228] the manufacturer cites recent studies, including several by Dr. Ho, in support of its new position. While it may be true that these studies on human volunteers have not produced evidence of impaired breathing or acidosis, they fall far short of satisfying me that multiple deployments of a conducted energy weapon do not have the *capacity* to increase these medical risks. Being satisfied that there are medical risks associated with the normal deployment of these weapons (as discussed earlier in this part), it would be imprudent of me to conclude, based on the human studies conducted to date, that those risks for some unexplained reason evaporate in the case of multiple deployments. To the contrary, prudence dictates that I should proceed on the assumption that multiple deployments increase at least some of the medical risks identified earlier in this part.

In a recent interview, Dr. Pierre Savard, one of the presenters at our policy hearings, described the results of his recent statistical analysis of 300 conducted energy weapon-related deaths reported by Amnesty International and 3,200 RCMP weapon deployments as compiled by CBC/Radio-Canada and Canadian Press. He stated: "What is really new here is the high level of relationship between the duration and the risk of death. It's a linear relationship. The more you are exposed, if you double the exposure, you double the risk of death."[229]

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228 See http://www.taser.com/training/Pages/TrainingResources.aspx.

229 "Hit him again: Are two blasts from a Taser more dangerous than one? What about five?" CBC News (March 25, 2009). See http://www.cbc.ca/national/blog/special_feature/a_deadly_landing/the_taser_test_1.html.

H. THE IMPACT OF WEAPON USE ON INJURIES AND FATALITIES

1. Introduction

While much of the discussion in this part has focused on identifying the medical risks associated with use of conducted energy weapons, it is important to balance that discussion with an acknowledgment of the benefits accruing from their use.

Thomas Smith, the chairman of TASER International, Inc., told me that 350,000 officers in 12,750 agencies in more than 40 countries use their weapon, with nearly 550,000 actual field uses. In the vast majority of cases, the officer achieves compliance (through pain or incapacitation) with only minor injury or no injury at all to the subject.

The manufacturer goes further. Mr. Smith told me that use of conducted energy weapons reduces officer injuries, reduces subject injuries, reduces the incidence of resorting to lethal force, and reduces professional standards complaints alleging excessive force. For example, according to the manufacturer's data, officer injuries have dropped between 23 and 83 percent in eight American cities, while suspect injuries have dropped between 24 and 80 percent.[230]

2. The experience in British Columbia

There is no data readily available in British Columbia applicable specifically to conducted energy weapons, and I am reluctant to extrapolate the American experience, as reported by the manufacturer, to the Canadian context.

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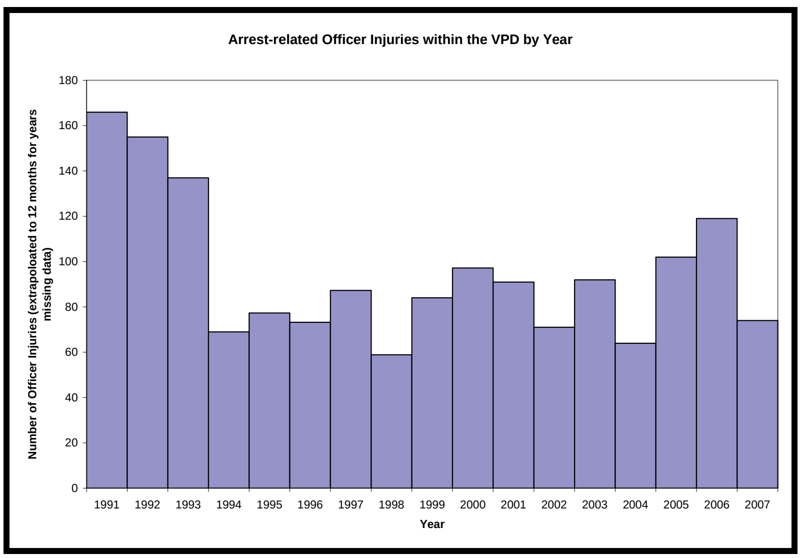
230 The data provided by the manufacturer gives no indication of who conducted the studies that produced these results, or what methodology was followed. In addition, the data gives no indication of the experience in all other cities—have they experienced similar, better, or worse outcomes? Researchers at the University of Central Florida criticized these studies as deriving from "weak research designs that reduce confidence in the validity of the results." See Adams, Kenneth and Victoria Jennison, "What We Do Not Know About Police Use of Tasers," (2007) 30:3 *Policing: An International Journal of Police Strategies & Management,* 447 at 461.

Consequently, the Commission obtained data from the Vancouver Police Department and WorkSafe BC (formerly Workers Compensation Board) regarding work-related injury claims made by police officers, sheriffs and bailiffs, and correctional workers.

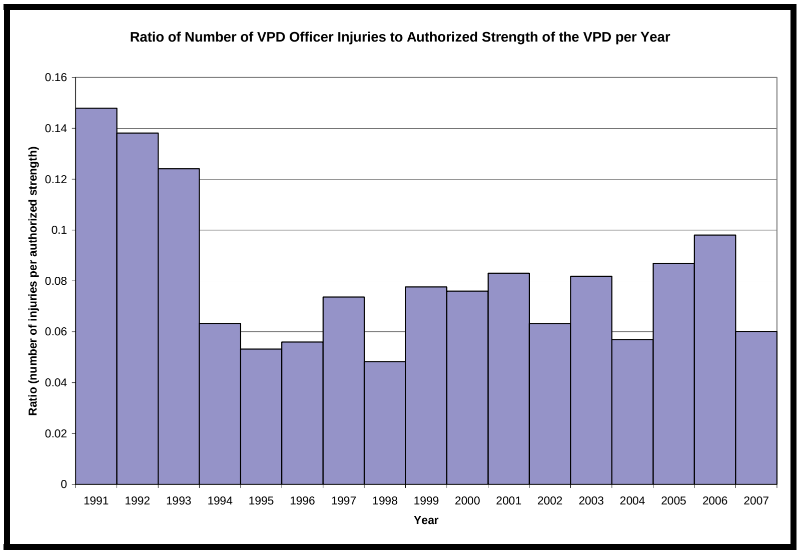
Commission researchers were able to extract arrest-related injuries from data supplied by the Vancouver Police Department, and then matched them to workers' compensation claims made by department employees. The analysis shows no significant difference in arrest-related injuries in the six years immediately preceding introduction of the weapon (in 2000) and in the eight years that the weapon has been used (see Graph 3).

Graph 3: Arrest-related officer injuries in Vancouver Police Department



The results did not change when increases in the authorized strength of the department during this period were taken into account (see Graph 4).

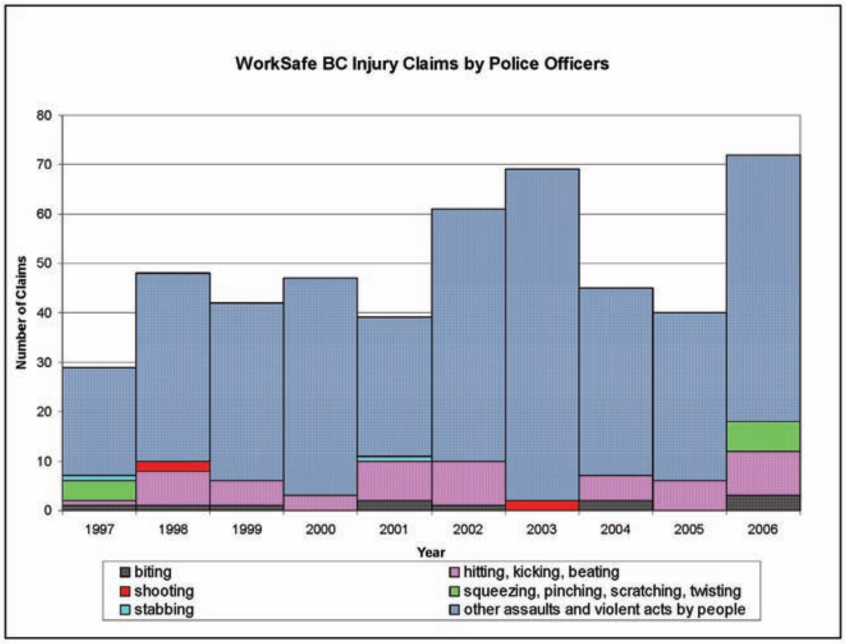
Graph 4: Ratio of number of VPD officer injuries to authorized strength



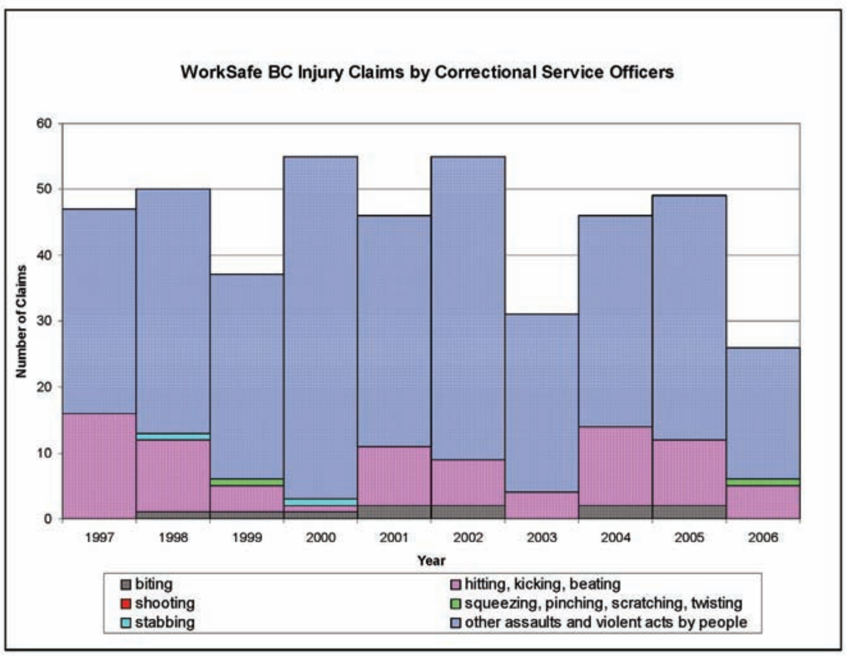
Commission researchers also examined WorkSafe BC tables listing the number of occupational injuries, sorted by occupation and by type of injury, for the years 1997 to 2006, which includes provincially regulated law enforcement agencies. They tallied this data, isolating those types of injuries that most likely captured confrontational situations with civilian suspects (*e.g.,* biting, kicking, stabbing).

In the case of police officers (Graph 5) and correctional service officers (Graph 6), there is no obvious consistent decline in arrest-related injuries since conducted energy weapons were introduced between 1998 and 2003. In the case of sheriffs and bailiffs (Graph 7) there has been a dramatic reduction in injuries beginning in 2003, two years after conducted energy weapons were introduced. However, I approach that data with caution, given the small number of claims.

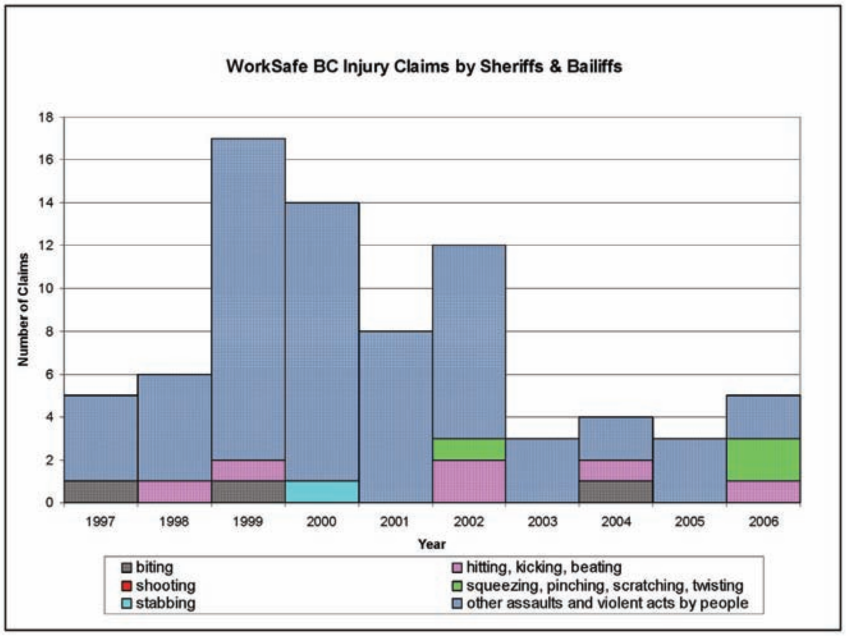
Graph 5: WorkSafe BC injury claims by police officers



Graph 6: WorkSafe BC injury claims by correctional service officers



Graph 7: WorkSafe BC injury claims by sheriffs and bailiffs



3. Canadian studies

The Canadian Police Research Centre is currently sponsoring a study comparing injury rates resulting from conducted energy weapon use with injury rates resulting from the application of other use-of-force techniques, such as batons and pepper spray. The study is scheduled for release in 2009, after peer review.

4. International studies

A British study found that officer and subject injury rates associated with deployment of the X26 conducted energy weapon were lower than injury rates for pepper spray and baton use (and, in the case of subject injuries, use of police dogs).[231] The authors acknowledged weaknesses in the data provided by the manufacturer. It was collected from law enforcement agencies on a voluntary basis using an incentive scheme, there

231 Jenkinson, E., et al., "The Relative Risk of Police Use-of-Force Options: Evaluating the Potential for Deployment of Electronic Weaponry," (2006) 13 *Journal of Clinical Forensic Medicine* 229.

was no control mechanism ensuring that agencies provided complete records, and some police agencies prohibit the release of such data altogether.

Criminologists at the University of South Carolina examined data on 1,645 use-of-force incidents from the Miami-Dade Police Department in Florida and the Richland County Sheriff's Department in South Carolina, between 2002 and 2006. The results were mixed.[232] In the case of one agency, the use of conducted energy weapons was associated with reduced odds of officer and suspect injury, and reduced severity of suspect injury. In the other agency, conducted energy weapon use was unrelated to the odds of injury, although the use of pepper spray was associated with reduced odds of suspect injury. The researchers also found that in both agencies the use of hands-on tactics by police was associated with increased odds of officer and suspect injury, and the use of canines was associated with increased odds of suspect injury. They suggested that a variety of factors affect the number of injuries associated with conducted energy weapon use, including agency type, agency size, amount of training, placement of these weapons on the use-of-force continuum, and use-of-force policy language.

A study funded by the U.S. National Institute of Justice, completed in 2008, examined the incidence and severity of injuries associated with conducted energy weapon use.[233] Described as the first prospective large-scale multicentre observational trial, researchers collected data on 1,201 conducted energy weapon incidents from six law enforcement agencies across the U.S.A. They categorized subject injuries as none, mild, moderate, and severe. The results are set out in Table 13.

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232 Smith, M.R., et al., "The Impact of Conducted Energy Devices and Other Types of Force and Resistance on Officer and Suspect Injuries," (2007) 30 *Policing: An International Journal of Police Strategies & Management* 423. See http://www.emeraldinsight.com/Insight/viewContentItem.do;jsessionid=AC1A5B39140D3CE95B105B699B9A294D?contentType=Article&contentId=1622104.

233 Bozeman, William P., et al., "Safety and Injury Profile of Conducted Electrical Weapons Used by Law Enforcement Officers Against Criminal Suspects," to be published in *Annals of Emergency Medicine*; see http://www.acep.org/pressroom.aspx?id=43742.

Table 13: Severity of injuries associated with conducted energy weapon use

Severity of injury	Number	Percentage
No injury	938	78.1
Mild injury*	260	21.6
Moderate injury	2	0.2
Severe injury	1	0.1

**"Mild" injury was defined broadly to include puncture wounds, contusions, lacerations, other soft tissue injuries, fractures, a broken tooth, and an epistaxis (nosebleed).*

Two of the three subjects who experienced moderate or severe injuries suffered head injuries sustained from falls, and the third involved a case of rhabdomyolysis. In addition, two subjects died within minutes of a second weapon discharge. They both had struggled violently with the police before and after conducted energy weapon use, and physical force was used to take them into custody. According to medical examiners, weapon use was not determined to be causal or contributory to either death. The researchers concluded, in part:

> Although this study of 1,201 consecutive conducted electrical weapon uses with subsequent medical screening does not document any cases with an immediate fatal collapse suggesting conducted electrical weapon-induced dysrhythmia, the possibility is not excluded.

With respect to the two subjects who collapsed and died soon after a second weapon discharge (five and 20 minutes respectively), both were agitated, one had a history of mental illness with a high level of an antipsychotic drug in his blood while the other had cocaine in his blood, both struggled extensively with officers, and one was restrained in the prone position. They are both instances of "death proximate to conducted energy weapon use." Regardless of whether the weapon's electrical current can be shown to have caused or contributed to the deaths, they reflect a commonly recurring pattern of subject behaviour and officer response leading to unexpected death.

This study did not purport to address the issue of whether the use of conducted energy weapons reduces injuries to officers and subjects. Another study funded by the National Institute of Justice, and currently underway, goes this next step, by investigating the relationship between various police use-of-force techniques and their outcomes.[234] It includes an analysis of injuries, before and after adoption of conducted energy weapons, from police departments in Orlando, Florida, and Austin, Texas. Although the full study has not yet been published, a summary presented to the National Institute of Justice in July 2008 included the statement that "the use of TASERS significantly reduced injuries to officers and citizens."[235]

5. Deaths

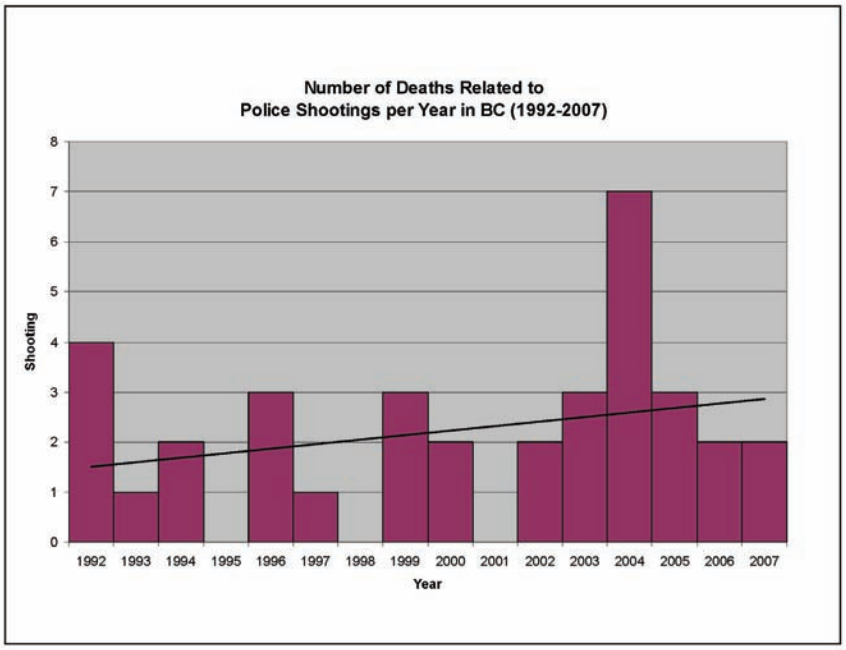
Advocates of conducted energy weapons contend that in some circumstances the weapon can be used as an alternative to a firearm, thereby saving lives. During the public forums I heard many anecdotal accounts of real-life situations in which a conducted energy weapon was successfully deployed against a subject armed with a weapon. In many of these accounts, the implication was that if a conducted energy weapon had not been used, a firearm would have been, with deadly consequences. I approach this line of reasoning cautiously, because it is speculative—we do not know whether other use-of-force techniques would have been effective, or whether the factual circumstances may have suddenly changed.

If the advent of conducted energy weapons has resulted in fewer subjects being shot by police officers, one would expect that change to be reflected in police-shooting data. Commission researchers examined statistics compiled by the BC Coroners Service showing the number of police-shooting deaths in BC between 1992 and 2007 (see Graph 8). This data shows a modest increase, not a decline, since the introduction of conducted energy weapons, and the results do not change when population increases are taken into account (see Graph 9). Given the small numbers involved, it would be unwise to generalize from this limited data.

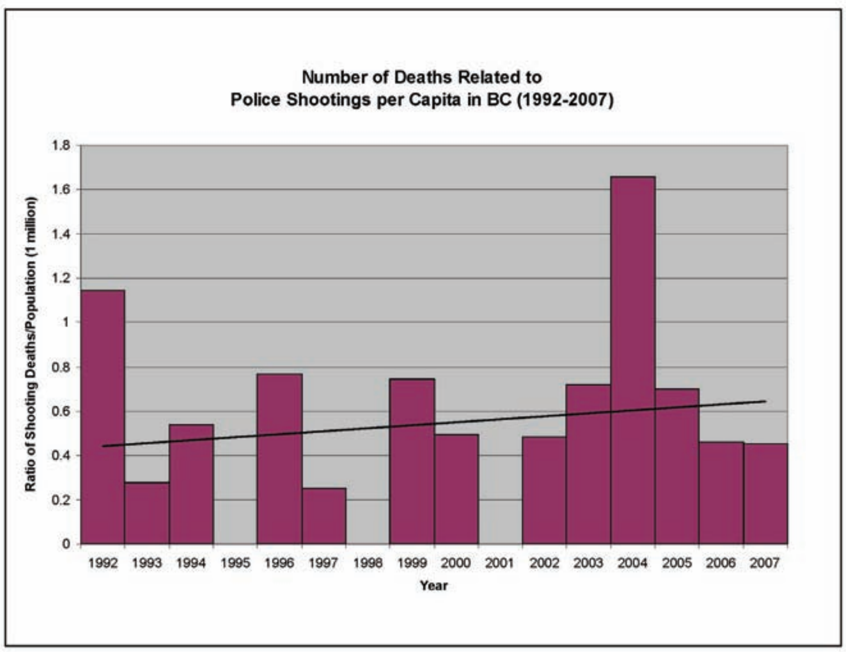
234 Smith, M.R., et al., "A Multi-Method Evaluation of Police Use of Force Outcomes," July 2008 [not yet published].

235 *Ibid*., slide 13.

Graph 8: Number of police-shooting deaths in British Columbia



Graph 9: Number of police-shooting deaths in British Columbia, per capita



It is noteworthy that a recent analysis of RCMP data led the Commission for Public Complaints Against the RCMP to conclude: "The nature of the circumstances that gave rise to CEW usage reports generally does not support the members' claims that CEW use assisted in avoiding lethal force in more than half of all CEW incidents in 2008."[236]

A recent American study[237] collected data by survey from police and sheriff's departments about unexpected in-custody deaths during non-lethal force situations in 50 moderate-sized California cities. It tabulated the number of deaths per 100,000 arrests during the five years preceding deployment of conducted energy weapons, during the year of deployment, and during the five years after deployment. The analysis took into account fluctuations in the number of arrests from year to year. A similar analysis was done of lethal force (officer firearm-related) deaths. The results are summarized in Table 14.

Table 14: In-custody deaths per 100,000 arrests, before and after deployment of conducted energy weapons

Deployment years of conducted energy weapons	In-custody deaths per 100,000 arrests	Lethal force deaths per 100,000 arrests
1-5 years before deployment	0.93	6.6
Year of deployment	0.61	14.1
First full year after deployment	5.96	15.1
2-5 years after deployment	1.44	9.1

The analysis showed a statistically significant increase in deaths in the first full year after deployment (and in the year of deployment, in lethal force deaths). Death rates then decreased to pre-deployment levels after the first full year of deployment, which the researchers explained as follows:

> We speculate that early liberal use of Tasers may have contributed to these findings, possibly escalating some confrontations to the point that firearms were necessary. The later decrease in sudden deaths and [lethal force deaths]

236 *RCMP Use of the Conducted Energy Weapon (CEW): January 1, 2008*, Special Report dated March 31, 2009, p. 31, available at http://www.cpc-cpp.gc.ca/prr/rep/sir/cew-ai-09-eng.aspx#sum.

237 Lee, Byron K., et al., "Relation of Taser (Electrical Stun Gun) Deployment to Increase in In-Custody Sudden Deaths," (2009) 103:6 *Am. J. Cardio*. 877.

> may reflect recognition of the adverse consequences of Taser application by law enforcement agencies, leading to an adjustment of usage and/or techniques to result in the observed decrease in the 2 events to pre-deployment levels.

I find this study valuable for several reasons. First, it is the kind of large-scale analysis that is needed if we are to make progress in quantifying the risks associated with the use of conducted energy weapons. Second, it reveals that the incidence of in-custody deaths did not drop following introduction of conducted energy weapons in these 50 communities. Third, the incidence of in-custody deaths is approximately one in 100,000 arrests, a ratio that must be borne in mind when balancing the benefits and risks in deploying these weapons.

The U.S. National Institute of Justice is currently conducting a study to address whether conducted energy weapons can contribute to or cause mortality and, if so, in what ways. A medical panel is conducting an undisclosed number of mortality reviews of conducted energy weapon-related deaths, and is reviewing the current state of medical research relative to the effects of such weapons. In its June 2008 *Interim Report*,[238] the medical panel's consensus view included the following findings:

- Although the exposure to conducted energy weapons is not risk free, there is no conclusive medical evidence within the state of current research that indicates a high risk of serious injury or death from the direct effects of weapon exposure.
- There is no medical evidence that weapons pose a significant risk for induced cardiac dysrhythmia when deployed reasonably, or that exposure produces sufficient metabolic or physiological effects to produce abnormal cardiac rhythms in normal, healthy adults. However, thin stature and dart placement in the chest may lower the safety margin for cardiac dysrhythmia.
- All aspects of an altercation constitute stress that may represent a heightened risk in individuals who have pre-existing cardiac or other significant disease.
- "Excited delirium" that requires restraint carries with it a high risk of death, regardless of the method of restraint. Current human research suggests that the use of a conducted energy weapon is not a life-threatening stressor in

238 National Institute of Justice Special Report, *Study of Deaths Following Electro Muscular Disruption: Interim Report*, available at http://www.ncjrs.gov/pdffiles1/nij/222981.pdf.

cases of "excited delirium" beyond the generalized stress of the underlying condition or appropriate mode of restraint.

- The purported safety margins of weapon deployment on normal, healthy adults may not be applicable in small children, those with diseased hearts, elderly people, those who are pregnant, and other at-risk individuals. The effects of weapon exposure in these populations are not clearly understood, and deployment against these populations should be avoided but may be necessary if the situation excludes other reasonable options.
- The medical risks of repeated or continuous weapon exposure are unknown and the role of such weapons in causing death is unclear in such cases. Caution is urged in using multiple activations of the weapon as a means of subduing a subject.
- Exposure is safe in the vast majority of cases, so law enforcement need not refrain from deploying weapons, provided they are used in accordance with accepted national standards. The decision whether or not to deploy a conducted energy weapon is best left to the tactical judgment of trained law enforcement at the scene.

6. Observations

I am reluctant to draw firm conclusions from the data and studies cited above. It is notoriously difficult to isolate a particular weapon's impact on injuries and deaths, when so many variables are at play. Further, no one knows how a police intervention would have turned out, had a conducted energy weapon not been available.[239] As Vancouver Police Department Deputy Chief Constable Bob Rich so aptly put it, the police don't have a "fixed control environment."[240]

Having said that, it would not be surprising if injuries to police officers are reduced when a conducted energy weapon is used in place of another use-of-force weapon or technique. Experience suggests that, by deploying conducted energy weapons, officers can frequently avoid (or at least minimize) physical altercations with subjects.

What is not so clear is whether injuries to subjects are reduced and, if so, to what extent. In many cases, a conducted energy weapon causes less injury than would a baton or a police dog, but that benefit must be balanced against the risk (however

239 Transcript, May 14, 2008, p. 45.
240 Transcript, May 14, 2008, p. 46.

small) of death or serious injury from everything from a fall to ventricular fibrillation. This calls for a risk-benefit analysis, which I will discuss in the next part.