Autopsy Errors with Electronic Control Devices: A Cardiovascular Perspective

Mark W Kroll, PhD, FACC, FHRS
Faculty of UCLA Creativity and Innovation Program
Adjunct Full Professor, Biomedical Engineering, Cal Poly Univ.
Adjunct Full Professor Biomedical Engineering, U of Minnesota
Taser Intl Scientific and Medical Advisory Board.
Co-Authors

- Jeffrey D. Ho, MD, Dept. of Emergency Medicine, Hennepin County Medical Center, Mpls, MN.
- Dorin Panescu, PhD, Sunnyvale, CA.
- Igor R. Efimov, PhD, Washington Univ, St. Louis, MO.
- Richard M. Luceri, MD, Holy Cross Hospital, Ft. Lauderdale, FL.
- Patrick J. Tchou, MD, Cleveland Clinic, Cleveland, OH.
- Hugh Calkins, MD, Johns Hopkins Hospital, Baltimore, MD.
Electronic Control Devices are Replacing the Club

- Training Uses Cumulative
- Suspect Uses Cumulative
- Total Uses

1/1/00 5/15/01 9/27/02 2/9/04 6/23/05 11/5/06
In Custody Deaths Correlate with Handcuffs

Deaths In American Police Custody: A 12 MONTH SURVEILLANCE STUDY

Jeffrey D. Ho, MD, James R. Miner, MD, William G. Heegaard, MD, MPH, Robert F. Reardon, MD
University of Minnesota Emergency Medicine Program, Department of Emergency Medicine, Hennepin County Medical Center
Minneapolis, Minnesota

INTRODUCTION
Emergency physicians often care for suspects in police custody. Suspect and unexpected in-custody death (ICD) of a suspect is an alarming event that occurs at an unknown rate. There are many theories of causation, including drug intoxication, excited delirium and excessive use of force by police. There is currently not an adequate, universal method in place to track ICD events so it is difficult to know how often ICD occurs or what factors surround each event. Since ICD has recently been a popular media topic of human rights groups, this lack of a universal tracking method may lead to faulty conclusions regarding causation or association. This report uses a novel and prospective process to gather ICD data and analyzes the factors reported for significance.

METHODS
www.webclippings.com was prospectively queried for American ICD’s over a 12 month period. This data search service scour 1.5 billion sources daily for requested terms. Data was forwarded for analysis and included subject gender, age, ethnicity, arrest force and weapons used, time of collapse, any attempt to arrest and presence of illicit substance abuse. Custodial agencies were contacted for details as necessary. Descriptive statistics and chi-square tests for significance were used.

RESULTS
- 102 ICD’s reported
- 92.5% males
- Mean age 35.7 years (SD=9.8, range 16-75)
- 62.9% exhibited bizarre behavior and 62.3% had confirmed illicit drug use just prior to arrest.

POLICE FORCE USED:
- None 22
- Significant Hands-On 111
- Intermediate Weapons 84
- Immediate Force 15, TASER 50, Handcuffs 162
- Deadly 19

TIME TO COLLAPSE:
- Instantly 21
- Within 1st hour 85
- Between 1-48 hours 66

WHO DIES IN CUSTODY
A review of available media sources reveals the following statistics about people who die in police custody without trauma.

- 12.3% were shot with chemical spray
- 12.6% were hit with impact weapons
- 30.1% were hit with TASERS
- 68.5% were handled with officers
- 62.3% ingested drugs and/or alcohol
- 100% were handcuffed

SIGNIFICANT ASSOCIATIONS FOUND
- Impact Weapons were associated with death in the first 60 minutes (13/14, p=0.019)
- TASER device application was never associated with instantaneous death (9/50, p=0.801)

CONCLUSIONS
- ICD in America is largely an event involving males less than 45 years of age engaging in illicit substance abuse
- ICD appears to occur within the first 60 minutes when an intermediate impact weapon is used
- ICD appears to never occur simultaneously when a TASER device is used
- This poster represents a preliminary source of the known ICD data
- No current ICD database exists for analysis and we recommend that professionals from interested disciplines develop universal reporting guidelines to better track these events

LIMITATIONS
We recognize that the most significant limitation of this study is the very point that we are trying to call attention to. The fact that there is not a current, universal ICD database is concerning. Because we have relied on the media to report these, it is possible that we have not included every ICD that has occurred. And, although we have attempted to verify accuracy of each report, it is possible that inaccurate reporting of force factors and collapse times occurred. We believe that an opportunity for a national registry of ICD’s exists to further define and study this problem.
X26 Waveform

- Typical peak current: 3.3 amperes
- Typical peak loaded voltage: 1200 V
- Pulse average voltage: 400 V
- Main phase duration: < 100 μs
- Delivered charge: ~ 100 μC
  - At 70 μs it delivers about 80 μC
- Average current
TASER ECDs Off the Chart
(Well Below Safe VF Limits)

[Graph showing current versus duration, with lines indicating IEC and UL limits.]
So, How Can It Capture Skeletal Muscles but *Not* Affect the Heart?

- **Anatomy**
  - Skeletal muscles are on the outside of the body.
  - Heart is on the inside of the body.
  - Electrical current tends to favor the grain of the muscle by 10:1 vs. going against the grain.
    - So current tends to stay on the outside.
- **Optimal stimulation pulse widths are different:**
  - A-\(\alpha\) motor neuron chronaxie:
    - 50–150 \(\mu\)s
  - Heart for transcutaneous stimulation:
    - 4 ms = 4000 \(\mu\)s
Cleveland Clinic Study

- America’s top heart hospital 6 years in a row by U.S. News & World Report.
- Cocaine increased safety margin by 50-100%

Breathing Unimpaired

BASIC INVESTIGATIONS

Respiratory Effect of Prolonged Electrical Weapon Application on Human Volunteers

Jeffrey D. Ho, MD, Donald M. Dawes, MD, Laura L. Bultman, MD, Jenny L. Thacker, MD, Lisa D. Skinner, MD, Jennifer M. Bahr, MD, Mark A. Johnson, BS, James R. Miner, MD

Abstract

Background: Conducted electrical weapons (CEWs) are used by law enforcement to subdue combative subjects. Occasionally, subjects will die after a CEW has been used on them. It is theorized that CEWs may contribute to these deaths by impairing respiration.

Objectives: To examine the respiratory effects of CEWs.

Methods: Human volunteers received a 15-second application of electrical current from a CEW while wearing a respiratory measurement device. Common respiratory parameters were collected before, during, and after exposure. Health histories and demographic information were also collected.

Results: Fifty-two subjects were analyzed. Thirty-four underwent a 15-second continuous exposure, and 18 underwent three 5-second burst exposures. In the continuous application group, the baseline mean tidal volume of 1.1 L increased to 1.8 L during application, the baseline end-tidal CO₂ level went from 40.5 mm Hg to 37.3 mm Hg after exposure, the baseline end-tidal oxygen level went from 118.7 mm Hg to 121.3 mm Hg after exposure, and the baseline respiratory rate went from 15.9 breaths/min to 16.4 breaths/min after exposure. In the 5-second burst group, the baseline mean tidal volume increased to 1.35 L during application, the baseline end-tidal CO₂ level went from 40.9 mm Hg to 39.1 mm Hg after exposure, the baseline end-tidal oxygen level went from 123.1 mm Hg to 127.0 mm Hg after exposure, and the baseline respiratory rate went from 13.8 breaths/min to 14.6 breaths/min after exposure.

Conclusions: Prolonged CEW application did not impair respiratory parameters in this population of volunteers. Further study is recommended to validate these findings in other populations.
Medical Electrocution Occurs 500 Times Per Day

1. VF is either induced or not induced within 1-4 seconds.
2. Asystole or PEA are never induced.
3. The cardiac pulse disappears immediately.
4. The patient loses consciousness within 5-15 seconds.
5. A defibrillation shock—either internal or external—restores a sinus rhythm 99.9% of the time.
6. There is no increased risk of a later VF since electrical current does not linger in the body as a poison or drug might.
2005 Was A Bad Year for Science
The Index Case for 2005

- Ronald Hasse age 54
- Naked, on 26th floor
- Talking to aliens on his cell phone
- CPD and EMS show up
- TASER ECD is used to take him into custody
- Dies
Hasse Headlines

Chicago Sun-Times, Jul 29, 2005

- Taser Killed Man, Pathologist Finds.

- In the first ruling of its kind in the nation, the Cook County medical examiner's office has determined the Feb. 10 death of Ronald Hasse was caused by a Taser stun gun ...

- Hasse received a **five-second** electrical burst from the Taser, followed by a **57-second** charge, according to Dr. Scott Denton, a deputy medical examiner.
The primary cause of Hasse's death was electrocution from the use of the Taser, Denton said.

A contributing cause was methamphetamine intoxication, he said.

...55 µg/ml of methamphetamine -- 10% over lethal level...

But the illegal drug probably would not have killed Hasse without his getting "pushed over the edge" by the Taser's jolts, Denton said.

DME stressed that what was different was the long 57 second application which is what killed Hasse.
### ECD Download Shows that the Longer Application was the First — Not the Latter!

#### TASER Information

<table>
<thead>
<tr>
<th>Serial #</th>
<th>2000-022238</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model #</td>
<td>X26</td>
</tr>
<tr>
<td>X26 Software Version</td>
<td>1.5</td>
</tr>
<tr>
<td>Dataport CD Version</td>
<td>15.6</td>
</tr>
<tr>
<td>Record Date Range</td>
<td>02/10/2005 - 02/10/2005</td>
</tr>
<tr>
<td>Computer Time Zone</td>
<td>Central Standard Time</td>
</tr>
<tr>
<td>Using Daylight Saving Time</td>
<td>No</td>
</tr>
</tbody>
</table>

#### Downloaded By

<table>
<thead>
<tr>
<th>Name</th>
<th>Robert Quaid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dept</td>
<td>Chicago</td>
</tr>
<tr>
<td>Rank</td>
<td>Capt.</td>
</tr>
<tr>
<td>Windows Version</td>
<td>Windows NT(TM) Service Pack 1</td>
</tr>
</tbody>
</table>

#### Report Generated

02/10/05 15:50:31 (local)

#### Recorded Firing Data

<table>
<thead>
<tr>
<th>Seq</th>
<th>GMT Time</th>
<th>Local Time</th>
<th>Duration</th>
<th>Temp</th>
<th>Battery</th>
</tr>
</thead>
<tbody>
<tr>
<td>0:01</td>
<td>02/10/05 18:50:49</td>
<td>02/10/05 12:50:49</td>
<td>57</td>
<td>30</td>
<td>93</td>
</tr>
<tr>
<td>0:02</td>
<td>02/10/05 18:50:55</td>
<td>02/10/05 12:50:55</td>
<td>5</td>
<td>30</td>
<td>89</td>
</tr>
</tbody>
</table>

#### Recorded X26 Time Changes

<table>
<thead>
<tr>
<th>Seq</th>
<th>GMT Time</th>
<th>Local Time</th>
<th>Change Type</th>
</tr>
</thead>
</table>

End of Report.
What Really Happened?

- Hasse tried to kick and bite officers and threatened to infect police with HIV.
- A 57 second TASER hit dropped Hasse.
- Immediately after he resisted again.
- This time they need a 5 second therapy until they are able to get handcuffs on.
- Hasse then climbed into the stair-chair.
- Paramedics verify normal pulse and respiration.
- Hasse wheeled to elevator.
- Alert with eyes open going into elevator.
Chicago Paramedic
• Taken down 26 floors.
• Collapses on ground floor 8 minutes after ECD application.
• Defibrillation unsuccessful.
• Death clearly not caused by ECD:
  – Continued to struggle after first application.
  – Normal pulse after both applications.
  – Normal respiration after both applications.
  – Collapse 8 minutes not 8 seconds after ECD usage.
  – Failure of immediate defibrillation.
Autopsy Mentions of TASER ECDs

Autopsy Reports Mentioning TASER ECD

\[ y = 4.0286x - 8062.4 \]

\[ R^2 = 0.7342 \]
Scored Errors

- Failure to appreciate that with electrocution:
  1. pulse disappears immediately,
  2. there is loss of physical strength for continued resistance
  3. collapse occurs within 5-15 seconds
  4. VF rhythm is shown on a cardiac monitor
  5. immediate defibrillation is usually successful
Other Scored Errors

6. Blaming the ECD for cardiac physical changes
7. Inclusion of a publicity sensitive safe comment (e.g. “we were unable to eliminate the role” of the ECD)
8. Assuming prolonged ECD applications are more dangerous than other restraint techniques
9. Claiming that ECDs impair breathing
10. Presumption of a lethal synergy between stimulant drugs and the ECD
11. Use of the ECD in the “drive stun” mode only since this involves current passing between 2 very close electrodes
12. Unscientific emotional explanations such as “last straw” or “pushed over the edge.”
# The Scorecard

<table>
<thead>
<tr>
<th>Probable Error in Citing the ECD</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time to collapse ≥ 1 minute</td>
<td>21</td>
</tr>
<tr>
<td>Continued resistance after ECD application</td>
<td>16</td>
</tr>
<tr>
<td>Rhythm other than VF</td>
<td>12</td>
</tr>
<tr>
<td>Publicity sensitive comments</td>
<td>9</td>
</tr>
<tr>
<td>Assumed drug-ECD electrocution synergy</td>
<td>8</td>
</tr>
<tr>
<td>Discharge duration or parity</td>
<td>7</td>
</tr>
<tr>
<td>Failure of immediate defibrillation</td>
<td>7</td>
</tr>
<tr>
<td>Drive stun mode</td>
<td>6</td>
</tr>
<tr>
<td>“Last straw” or “over the edge”</td>
<td>6</td>
</tr>
<tr>
<td>Cardiac damage ascribed to ECD</td>
<td>4</td>
</tr>
<tr>
<td>Assumed ventilation impairment</td>
<td>3</td>
</tr>
</tbody>
</table>
Error Rate of $3.1 \pm 1.2$ per Autopsy

Data as of Abstract Submission
TASER-related Errors Dropping Fast!

Error Rate by Year of Death

Year of Death

2002 2003 2004 2005 2006 2007
Error Analysis Conclusions

- 90% of autopsies have no errors re the role of electronic control devices.
- Cardiogenic etiology errors are dropping rapidly.
- It is impressive that medical examiners have rapidly familiarized themselves with:
  - time and causation elements of electrocution,
  - ventricular fibrillation,
  - ECD technology, and
  - excited delirium