Conquering Refractory Ventricular Fibrillation in the Prehospital & Emergency Department Setting

Andrew J. Bowman
Acute Care Nurse Practitioner
Paramedic
OHCA

Recognition and activation of the emergency response system
Immediate high-quality CPR
Rapid defibrillation
Basic and advanced emergency medical services
Advanced life support and postarrest care

Lay rescuers
EMS
ED
Cath lab
ICU
Adult Cardiac Arrest Algorithm—2015 Update

1. Start CPR
   - Give oxygen
   - Attach monitor/defibrillator

2. Rhythm shockable?
   - Yes
     - VF/pVT
     - Shock
     - CPR 2 min
       - IV/IO access

3. Yes
   - Shock

4. CPR 2 min
   - IV/IO access
   - Epinephrine every 3–5 min
   - Consider advanced airway, capnography

5. Yes
   - Shock

6. CPR 2 min
   - Epinephrine every 3–5 min
   - Consider advanced airway, capnography

7. Yes
   - Shock

8. CPR 2 min
   - Amiodarone
   - Treat reversible causes

9. No
   - Asystole/PEA

10. CPR 2 min
    - IV/IO access
    - Epinephrine every 3–5 min
    - Consider advanced airway, capnography

11. No
    - CPR 2 min
        - Treat reversible causes

12. Rhythm shockable?
    - Yes
      - If no signs of return of spontaneous circulation (ROSC), go to 10 or 11
      - If ROSC, go to Post–Cardiac Arrest Care
    - No
      - Go to 5 or 7

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# Strategies for Refractory VF

<table>
<thead>
<tr>
<th>Strategies</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>High performance CPR</td>
<td>Optimize blood flow</td>
</tr>
<tr>
<td>Defibrillation</td>
<td>Optimize Defibrillation</td>
</tr>
<tr>
<td>Vasopressors</td>
<td>? Epinephrine</td>
</tr>
<tr>
<td>Antiarrhythmics</td>
<td>ALPS Study</td>
</tr>
<tr>
<td>Fix the Ischemia</td>
<td>Definitive Treatment for Ischemic VF</td>
</tr>
<tr>
<td>ECMO</td>
<td>Keep alive until fix ischemia</td>
</tr>
</tbody>
</table>
Dual Sequential Defibrillation (DSD)
“for the person with a heart and brain too good to die.”
<table>
<thead>
<tr>
<th>Date</th>
<th>Author</th>
<th>Subject</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>1986</td>
<td>Chang</td>
<td>Canine</td>
<td>Both healthy and induced infarcted canine hearts with induced VF. DSD shock terminated if single shock did not</td>
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<tr>
<td>1986</td>
<td>Jones</td>
<td>Human</td>
<td>21 healthy volunteers underwent induced VF in EP lab to single or double sequential defibrillation. DSD had lower defibrillation threshold, patients with repeated failed single shocks at max voltage had immediate successful DSD as “rescue”</td>
</tr>
<tr>
<td>1989</td>
<td>Brady</td>
<td>Human</td>
<td>16 OOHCA survivors were randomized and demonstrated lower defibrillation threshold with DSD</td>
</tr>
<tr>
<td>1994</td>
<td>Hoch</td>
<td>2,990 EP lab patients</td>
<td>5 patients with refractory VF resistant to single shocks. All 5 VF terminated with first DSD shock. All 5 survived</td>
</tr>
<tr>
<td>Date</td>
<td>Author</td>
<td>Subject</td>
<td>Conclusion</td>
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<td>-----------------------------------------------------------------------------</td>
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<tr>
<td>2014</td>
<td>Cabanas</td>
<td>OOHCA 10 patients</td>
<td>Successful conversion to NSR in 7/10 patients Unfortunately no survivors</td>
</tr>
<tr>
<td>2014</td>
<td>Gerstein</td>
<td>DSD IHCA</td>
<td>Successful DSD defibrillation after 74 minutes of resuscitation</td>
</tr>
<tr>
<td>2015</td>
<td>Lybeck</td>
<td>40 yo OHCA with VF from commotio cordis</td>
<td>DSD on 8\textsuperscript{th} attempt CT cardiac contusion. Normal coronaries on cath. DC with full neurological function</td>
</tr>
<tr>
<td>2016</td>
<td>Bowman</td>
<td>21 yo with SAD</td>
<td>DSD on 8\textsuperscript{th} defibrillation attempt Conversion to SR Cath -&gt; normal coronaries DC with CPC 1, back to college, AICD</td>
</tr>
<tr>
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<td>Conclusion</td>
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<tr>
<td>2016</td>
<td>Johnston</td>
<td>28 yo OHCA</td>
<td>CPR</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>6 single shocks</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1 DSD w ROSC</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Dx w LQT, AI CD, CPC 2</td>
</tr>
<tr>
<td>2016</td>
<td>Ross</td>
<td>3 Years 3470 OHCA</td>
<td>302 refractory VF</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>279 complete data</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>50 DSD, 229 No DSD</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>No significant survival difference</td>
</tr>
<tr>
<td>2016</td>
<td>Cortez</td>
<td>4 Years 2428 OHCA</td>
<td>12 DSD</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>9 converted out of VF</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3 ROSC</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2 w CPC 1</td>
</tr>
<tr>
<td>2016</td>
<td>Jui</td>
<td>Prospective Study</td>
<td>28 patients</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>12 w conversion from VF</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>9 w ROSC</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3 survivors w CPC 1-2 (ages 27-81)</td>
</tr>
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Dual Sequential Defibrillation
• Possible larger current density and more even distribution over myocardium

• More myocytes depolarized

• Prolonged shock duration depolarizing more myocytes

• More energy
Figure 1. Placement of defibrillator pads.
Double Sequential Defibrillation – Adult

PARAMEDIC STANDING ORDERS – ADULT

INDICATION: Refractory Ventricular Fibrillation / Tachycardia after 5 unsuccessful shocks

- Recurrent ventricular fibrillation/tachycardia is defined as SUCCESSFULLY CONVERTED by standard defibrillation techniques but subsequently returns. It should NOT be treated by double sequential external defibrillation. It is managed by treatment of correctable causes and use of anti-arrhythmic medications in addition to standard defibrillation.
- Refractory ventricular fibrillation/tachycardia is defined as NOT CONVERTED by standard defibrillation. It is initially managed by treating correctable causes and with antiarrhythmic medications. If these methods fail to produce a response, double sequential external defibrillation may be beneficial.

PROCEDURE:
1. Prior to attempting Double Sequential Defibrillation, at least one shock should be given using a different vector. Change pad placement from anterior-apex to anterior-posterior.
2. Ensure quality CPR and minimally interrupted chest compressions during pad application and procedure.
3. Apply a new set of external defibrillation pads adjacent to, but not touching the pad set currently in use.
4. Assure that controls for the second manual defibrillator are accessible to the team leader.
5. Verify that both cardiac manual defibrillators are attached to the patient, that all pads are well adhered, and simultaneously charge both manual defibrillators.
6. When both monitors are charged to maximum energy settings and all persons are clear, push both shock buttons as synchronously as possible.
7. May repeat procedure every 2 minutes as indicated if refractory ventricular fibrillation/tachycardia persists.

PEARLS
- Continue compressions when defibrillators are charging.
- During interruptions compressor’s hands should hover over chest.
- Pre-charge manual defibrillators prior to rhythm check to ensure rapid defibrillation if a shockable rhythm is present. If no shock is indicated, disarm the device (dump the charge).
- Depending your local hospital resources, some refractory ventricular fibrillation patients may benefit from emergent cardiac catheterization. For this small patient population, transportation (ideally with a mechanical CPR device) may be indicated. Transporting these patient directly to the cath lab should be done in collaboration with on-line medical control and interventional cardiology.

Photo Courtesy of Emergency Medicine Reviews and Prespectives
Refractory VF Treated with Esmolol

- Lee et al
- Resuscitation October 2016

- 41 patients
- OHCA with refractory VF
- 25 No Esmolol
- 16 Esmolol
- Load 500mcg
- Infusion 0 - 100mcg/ kg/ min
<table>
<thead>
<tr>
<th></th>
<th>Esmolol</th>
<th>No Esmolol</th>
</tr>
</thead>
<tbody>
<tr>
<td># Patients</td>
<td>16</td>
<td>25</td>
</tr>
<tr>
<td>Sustained ROSC</td>
<td>56.3%</td>
<td>16%</td>
</tr>
<tr>
<td>Survive to ICU</td>
<td>56.3%</td>
<td>16%</td>
</tr>
<tr>
<td>Survive 30d</td>
<td>18.8%</td>
<td>8%</td>
</tr>
<tr>
<td>Good Neuro 30d</td>
<td>18.8%</td>
<td>8%</td>
</tr>
<tr>
<td>3mo Survive</td>
<td>18.8%</td>
<td>8%</td>
</tr>
<tr>
<td>Good Neuro 3mo</td>
<td>18.8%</td>
<td>8%</td>
</tr>
</tbody>
</table>
Esmolol After Failure Standard CPR with Refractory VF

- Driver et al
- Resuscitation October 2014

- 25 patients
- 19 No esmolol
- 6 Esmolol
<table>
<thead>
<tr>
<th>Endpoint</th>
<th>Esmolol</th>
<th>No Esmolol</th>
</tr>
</thead>
<tbody>
<tr>
<td>ROSC</td>
<td>67%</td>
<td>42%</td>
</tr>
<tr>
<td>Sustained ROSC</td>
<td>67%</td>
<td>32%</td>
</tr>
<tr>
<td>ICU Survival</td>
<td>66%</td>
<td>32%</td>
</tr>
<tr>
<td>DC Survival</td>
<td>50%</td>
<td>16%</td>
</tr>
<tr>
<td>Favorable Neuro DC</td>
<td>50%</td>
<td>11%</td>
</tr>
</tbody>
</table>
First Report of Survival in Refractory VF after DSD and Esmolol

• Boehm et al
• November 2016
• Western Journal of Emergency Medicine
• 67 yom
• Hx LAD stent
• ED CP with CPA
• VF

• First 15 minutes
  – 5 single shocks
  – Epi 1 mg x 4 doses
  – Amiodarone 450mg
• Decision to use DSD & Esmolol

• DSD x 1, no change
• Esmolol 80mg IVP (~1000mcg/ kg)
• Esmolol 0.1mg/ kg/ hr (~133mcg/ min)

• Circulated x 3 minutes

• 2\textsuperscript{nd} DSD with ROSC and waking up

• Cath lab with LAD lesion/ stent
Dual Sequential Defibrillation (DSD)

Esmolol