Proposal For The Use of Double Sequential Defibrillation For The Treatment of Refractory Ventricular Fibrillation or Pulseless Ventricular Tachycardia by EMS in Manitoba

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Introduction

Your patient is a 57 year old male who collapsed after a few hours of feeling "unwell" and then a sudden onset chest pain. On arrival you find a police officer performing chest compressions. Once the defibrillator pads are placed on the patient, you can see that he is in Ventricular Fibrillation, and you immediately charge the defibrillator and deliver the first shock. One of your team takes over chest compressions, and another secures the airway and starts ventilations. You gain vascular access, and start down the Cardiac Arrest Algorithm.

After multiple shocks, Epinephrine and Antiarrhythmic administration, your patient stubbornly refuses to convert and remains in Ventricular Fibrillation. Now what? You have worked on this patient for over 30 minutes. Do you transport, knowing that your compressions during patient movement and while on route will be mostly ineffectual? What will happen at the receiving facility of the VF cannot be terminated? Or is there something else you can do on scene?

This is a proposal to provide Manitoba Paramedics another treatment for the above patient. It is known as Double Sequential Defibrillation, or Dual Sequential Defibrillation. I will provide a background of this procedure, show where it should appear in the Cardiac Arrest Care Map, and give references to studies and other EMS Departments who are currently using this in their practice.

Definition of Refractory Ventricular Fibrillation or Pulseless Ventricular Tachycardia

For the purpose of this proposal, we shall define refractory ventricular fibrillation or Pulseless Ventricular Tachycardia as VF/Pulseless VT unresponsive to at least three shocks, three doses of epinephrine 1mg, and two administrations of an Antiarrhythmic drug (300mg followed by 150mg of Amiodarone or 100mg followed by 50 mg of Lidocaine). We could also consider VF/Pulseless VT to be refractory when a patient is converted to any other rhythm but returns to VF/Pulseless VT at least once.

What is Double Sequential Defibrillation

Double Sequential Defibrillation was first described in animal literature in the 1980's in an article presented in the Journal of American Cardiology.[1] The first human cardiology mention was from Yale-New Haven Hospital in Connecticut and St. Francis Hospital in New York. Five male patients with recurrent VF were treated with Double Sequential Defibrillation. All five were converted out of VF on the first attempt with DSD.[2]

So what is Double Sequential Defibrillation? The procedure requires the use of two defibrillators, delivering a shock simultaneously to the patient. Pads can be placed using two different methods.

- Method One: The first set of pads is placed in the traditional Anterior/Lateral position. The second set of pads is placed adjacent to the first set.
- Method Two: The first set of pads is placed in the anterior/lateral position. The second set of pads is placed in the anterior/posterior position.
- Both defibrillators are charged and the shocks delivered simultaneously by one operator.

There are a number of theories as to why DSD is effective. The first is that using multiple defibrillators, and delivering the shocks over multiple vectors will allow for the entire myocardium to be depolarized, which is what must happen to terminate the fibrillation. Another theory has to do with greater energy being utilized with two defibrillators. And a third theory suggests successful conversion may be a result of the length of time over which the energy is applied, referring to consecutive shocks, as opposed to simultaneous shocks.[3] One could also suggest that using Double Sequential Defibrillation could be helpful in overcoming the excessive impedance of patients with an endomorphic body habitus.

There is currently not enough data collected and analyzed for ILCOR to make any recommendation for or against the practice of DSD. Several retrospective studies exist, as well as many case studies and anecdotal information which show that using DSD in the presence of refractory VF may be, and in a number of cases, has been, successful in terminating the VF. Although not all patients have survived to discharge from the hospital, there have been documented cases of neurologically intact patients post resuscitation using this procedure. I have been unable to find any literature which indicates that DSD has caused more post arrest myocardial damage from either traditional or double sequential defibrillation.

[1] Chang MS, Inoue H, Kallok MJ, et al. Double and triple sequential shocks reduce ventricular defibrillation threshold in dogs with and without myocardial infarction. J Am Coll Cardiol. 1986;8(6):1393-1405.

[2] Hoch DH, Batsford WP, Greenberg SM, et al. Double sequential external shocks for refractory ventricular fibrillation. J Am Coll Cardiol. 1994;23(5):1141-1145.

[3] "Hold the Coroner"By John Erich www.EMSWorld.com October 10, 2011

How Would DSD Fit into the Cardiac Arrest Care Map

This recommendation is based on the Wake County EMS Persistent VT/VT Protocol (**see Appendix A**). Once the first and second dose of an antiarrhythmic has been administered, and no change is noted in the patient's rhythm after at least 20 minutes; or a patient is converted from VT/Pulseless VT into any other rhythm but subsequently returns to the VT/Pulseless VT, the provider could then initiate DSD. Alternatively, this could be a procedure that would require permission from Online Medical Control, again after at least one round of antiarrhythmic with no conversion.

Appendix B presents a revised Adult VT/Pulseless VT Algorithm as well as a proposed Adult Persistent VF/VT Algorithm.

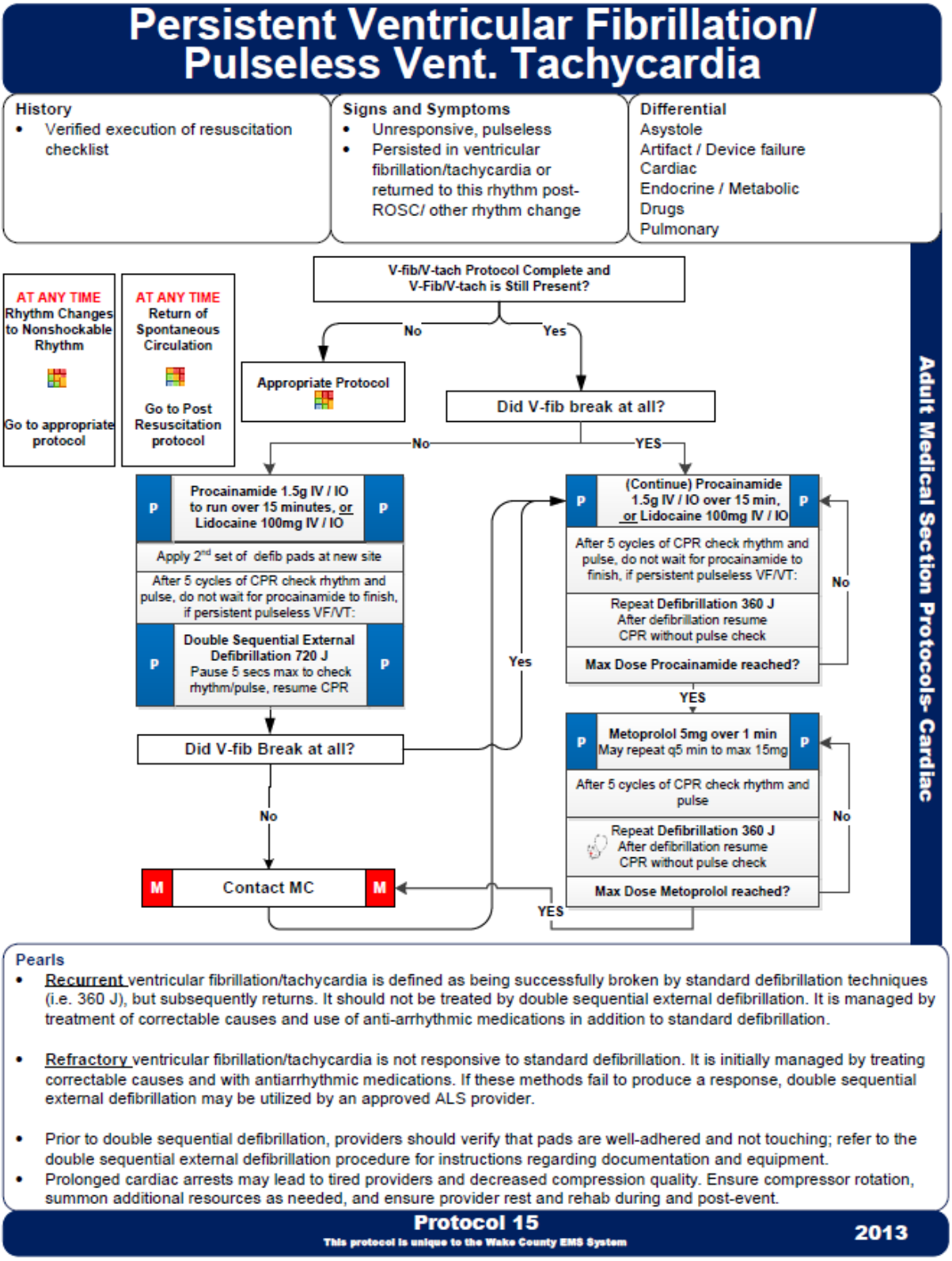
Why Should We Consider Attempting DSD

Back to our initial patient, for whom we have exhausted all standard treatments for the termination of ventricular fibrillation. There are only two choices (three if we consider the use of Esmolol for refractory VF, but that is for another time). We can terminate resuscitation, having nothing else to offer, or we can attempt Double Sequential Defibrillation. There are two possible outcomes; no conversion and we still terminate resuscitative efforts, or we convert the VF to a perfusing rhythm.

Pre Hospital and in hospital providers should be considering this as an option for treatment of refractory VF, and then ensuring that each attempt is documented, so that more data can be collected and shared. With enough uses, and hopefully successes, the next ECC guidelines may include a reference to DSD with a recommendation of offering no harm, but possible good for the patient.

There are already a number of EMS Agencies in North America who have incorporated DSD into their protocols. Close to home, Toronto EMS and PEEL EMS are both using DSD in an effort to collect data, and offer their cardiac arrest patients one final chance at recovery.

Appendix A - Wake County EMS Protocol for Persistent VF/VT and Procedure for Double Sequential Defibrillation



Standards Procedure (Skill)

Double Sequential External Defibrillation

P EMT- P P

Clinical Indications:

- Any patient who has persisted in ventricular fibrillation/tachycardia, without even transient interruption of fibrillation, as per the persistent VF/VT protocol.
- At least one shock was delivered using different pads applied so as to produce a different current vector than the first set and all other indicated treatment modalities have been implemented.
- A paramedic has verified the persistence of the arrhythmia immediately post-shock

Procedure:

1. Ensure quality of CPR is not compromised during prolonged efforts.
2. Prepare the sites for attachment of an additional set of external defibrillation pads by drying the sites and minimizing interference of hair or other obstacles to good pad adhesion.
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 cardiac monitor are accessible to the code commander
5. The approved enhanced care provider will verify that the resuscitation checklist has been fully executed
6. On rhythm check, the enhanced care provider will confirm the rhythm.

   a. If a shockable rhythm is detected, CPR will resume immediately. The enhanced care provider will verify that both cardiac monitors/defibrillators are attached to the patient, that all pads are well adhered, and direct the simultaneous charging of both attached cardiac monitors. When both monitors are charged to maximum energy and all persons are clear, the code commander or other paramedic will push both shock buttons as synchronously as possible. A brief rhythm/pulse check will occur and CPR will resume as appropriate.

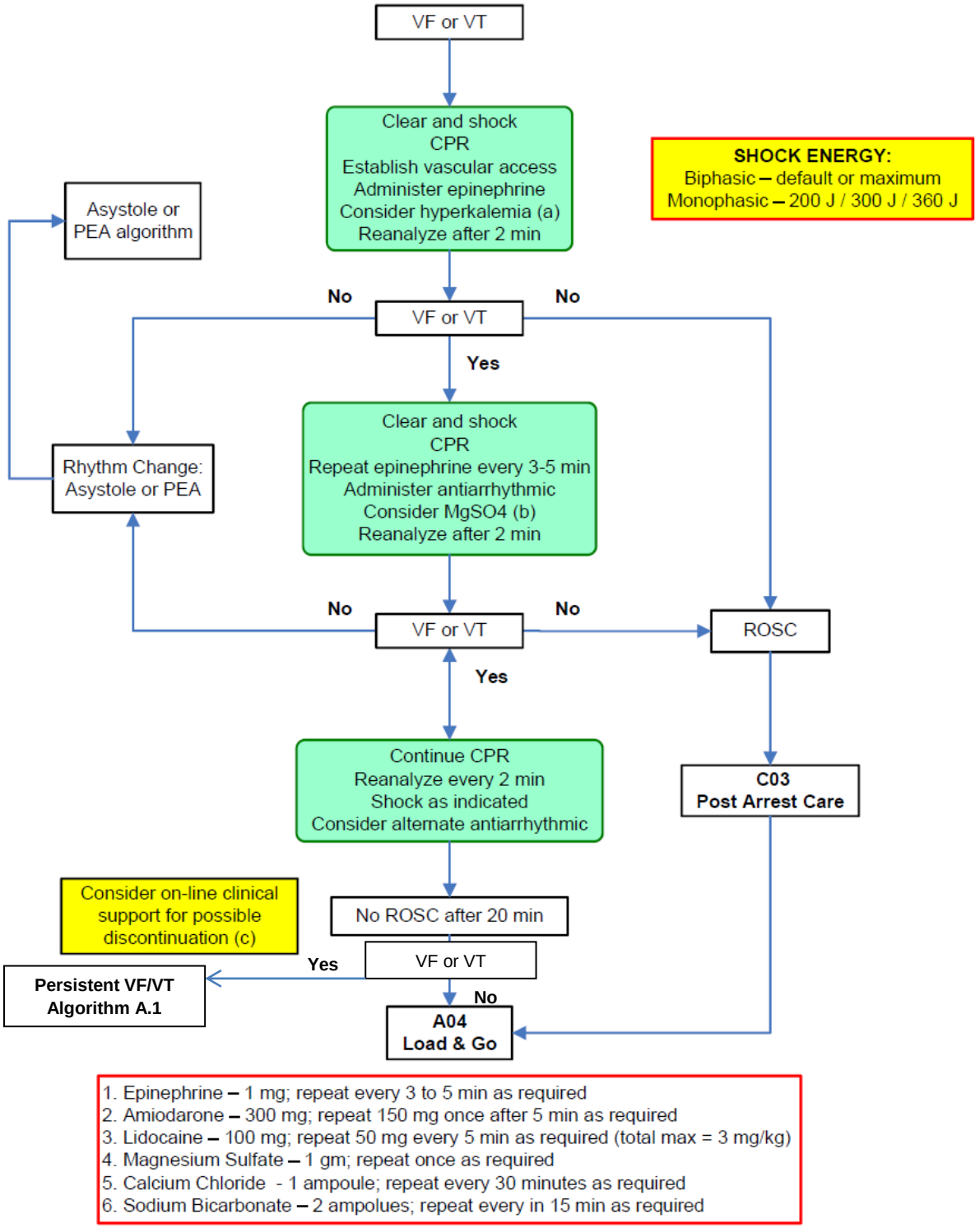
b. If a non-shockable rhythm is present care will resume according to the appropriate protocol.

Certification Requirements:

Maintain knowledge of the indications, contraindications, technique, and possible complications of the procedure. Assessment of this knowledge may be accomplished via quality assurance mechanisms, classroom demonstrations, skills stations, or other mechanisms as deemed appropriate by the Wake County EMS System. Assessment should include direct observation at least once per certification cycle.

Appendix B – Revised Adult VF/VT Algorithm A and Proposed Persistent VF/VT Algorithm A.1

A: Adult Ventricular Fibrillation or Pulseless Ventricular Tachycardia (VF/VT) Algorithm



A.1: Persistent VF/Pulseless VT Algorithm

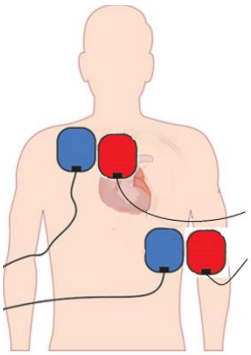
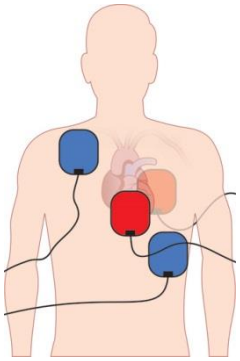
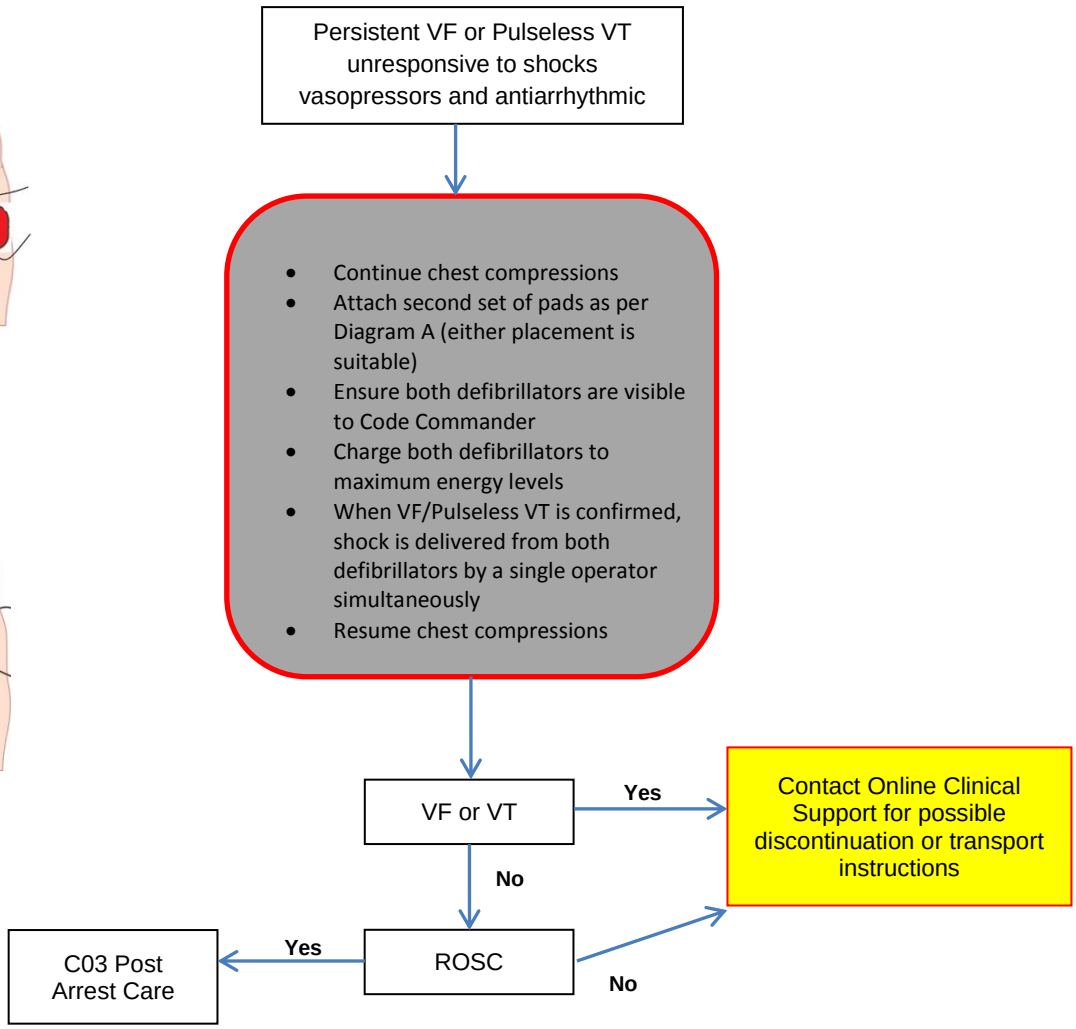


Diagram A: Pad Placement Options





Appendix C – Article: Using Double Sequential Defibrillation to Help Cardiac Arrest Patients

By David Neubert M.D.

Figure 1: Patient's ECG showing torsades de pointes

A 19-year-old male is a known heroin abuser to his friends and family, and after much encouragement he successfully completes rehab and comes home. In honor of his return, his friends invite him to a house party to celebrate. Initially, the night is going well, but soon his friends become concerned when no one can find him.

Someone mentions that he left about an hour ago to "get something from his car." His friends go outside to investigate, and find him slumped over in the back seat. He appears blue and is cold to the touch. There's drug paraphernalia next to him. Someone at the house party calls 9-1-1 in response to their screams for help. A friend sees a police car driving by and starts screaming and jumping up and down for help.

Meanwhile at Rescue 1, the dual paramedic crew is catching up on charts from the busy shift the night before. The tones suddenly activate for an "unresponsive male, possible overdose." The crew recognizes the address-they were there two weeks ago and had talked to a teenage male about entering rehab after waking him up with Narcan (naloxone). The address is less than five minutes from the station. The crew calls en route.

Back at the scene, the police officer exits his cruiser and immediately realizes something is seriously wrong. He pushes past the obviously excited and upset friends and sees the teenager slumped in the back seat, cyanotic and unresponsive. The officer opens the patient's airway and checks for a pulse.

There's no pulse, no breathing and he's cold to the touch. With the help of bystanders, the officer pulls the teenager onto the ground. He instructs them how to do chest compressions and runs to the cruiser to grab an AED from the trunk.

He radios dispatch, "Cardiac arrest with CPR in progress. Have EMS expedite." He returns to the patient's side and attaches the AED, but there's "no shock advised" so he continues CPR.

Rescue 1 pulls up a few minutes later and the crew radios for a second crew. The first medic takes control of the airway and starts to ventilate with a bag-valve mask (BVM) as the police officer continues compressions, and the second medic attaches the monitor.

The initial rhythm displayed on the monitor is asystole. As CPR continues, the patient's airway is suctioned of thickly pooled oral secretions and he's intubated without difficulty. An intraosseous line and an external jugular peripheral line are placed for access. Epinephrine is administered 1 mg 1:10,000 IV. Given that it's a suspected overdose with a possible toxidrome, 1 gram of calcium chloride and 150 mEq of sodium bicarbonate are also given.

On rhythm recheck, the patient is in v fib. He's subsequently defibrillated at 200 joules using a biphasic defibrillator. There's a brief return of spontaneous circulation (ROSC) with sinus tachycardia, but it quickly decompensates back to v fib. CPR continues, 300 mg of amiodarone is administered and the patient is again defibrillated at 200 joules. He's converted back to sinus rhythm with pulses. An amiodarone drip is initiated.

While obtaining a 12-lead ECG post ROSC, the patient's rhythm again decompensates, this time to torsades de pointes. (See Figure 1 above.) He's defibrillated again, this time at 360 joules. Two grams of magnesium is administered via IV. There's a brief ROSC again, to a sinus tachycardia, but the rhythm quickly deteriorates back to v fib. CPR is reinitiated. Lidocaine 100 mg and epinephrine 1 mg are given. The patient is defibrillated an additional three times at 360 joules, this time with no cardioversion.

Given that the patient is young, and all other avenues have been exhausted, the crew notifies medical control and requests permission to attempt double sequential defibrillation. The order is approved. Additional help has arrived at this point, and a second defibrillator is taken from the backup ambulance. The second monitor is attached to the patient, this time with the defibrillation pads placed in anterior-posterior positioning (the first set had been placed in standard apex-sternum orientation). (See Figure 2.) Both defibrillators are simultaneously charged to 360 joules. On the count of three, the medics simultaneously deliver shocks from both defibrillator units.

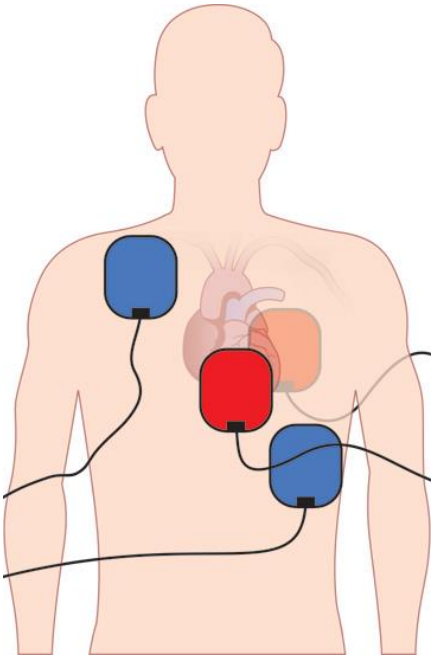


Figure 2: Placement of AED pads during double sequential defibrillation

The double sequential defibrillation is successful. The patient is converted to a normal sinus rhythm and there are no subsequent arrhythmias after the double sequential shocks. The patient is transported to the ED with fluids wide open, as he remains profoundly hypotensive. Pulse dose epinephrine is used to maintain a blood pressure en route to the hospital.

Hospital Course

In the hospital, a bedside ultrasound by the emergency physician shows grossly reduced cardiac wall motion globally. A post-resuscitation chest X-ray shows no significant lung injury or evidence of pneumothorax. The patient has a very labile blood pressure and episodes of sinus bradycardia after ROSC, which are corrected with a norepinephrine drip and an epinephrine drip. He's transferred to the ICU.

Post-resuscitation hypothermia protocol is initiated. After 48 hours of care, a head CT shows marked cerebral edema. A bedside apnea test demonstrates no evidence of spontaneous respirations after 10 minutes. A Tc-99m brain death (or intracerebral perfusion) scan is performed, and indicates no cerebral radionucleotide uptake. The patient is declared brain dead by neurology.

The family decides to participate in the Gift of Life program, and the patient's heart, lungs, pancreas, liver and kidneys are harvested for others in need.

Discussion

The concept of double sequential defibrillation shocks was initially described in animal literature in a mid-1980s article presented in the Journal of American Cardiology. Using a canine model, investigators delivered single, double and triple exponential shocks to hearts in which v fib and myocardial infarction had been induced. The shocks were delivered one second apart and employed different vectors (i.e., pathways) across the heart. The researchers determined that "two sequential shocks over different pathways reduce both total energy and peak voltage required to terminate ventricular fibrillation."[1] Thus, both sequential shocks and multiple vectors help to reduce the v fib threshold and therefore terminate the arrhythmia.

The first mention of double sequential defibrillation in human cardiology literature was from electrophysiology teams at Yale-New Haven Hospital (Conn.) and St. Francis Hospital (N.Y.). During routine electrophysiologic testing of nearly 3,000 patients over a three-year period, five male patients experienced recurrent ventricular dysrhythmias, predominantly v fib. These patients were undergoing standard programmed electrical stimulation, or having implantable defibrillator placement. The patients received between seven and 20 defibrillation shocks at 200 to 360 joules prior to double sequential defibrillation being employed. The double sequential technique worked during the first attempt in each patient. The shocks were delivered between 0.5 and 4.5 seconds apart. They used the anterior-posterior and apex-sternum orientations to deliver the shocks. No pharmacological agents were administered between the unsuccessful single defibrillation attempts and the successful double-sequential conversion.[2]

The teams theorized that the double-sequential shocks reduced the v fib threshold, may override the relative refractory period of cardiac muscle, or possibly decrease transthoracic impedance, leading to a more effective electrical delivery. They also felt that the change in vectors played a factor, effectively using the first shock to "set up" for the subsequent shock. They concluded their article with the statement, "This technique may have general applicability to the emergency room setting, providing a simple and potentially lifesaving approach to refractory ventricular fibrillation."[2]

More recently, there was a retrospective case series published in Prehospital Emergency Care from a high-volume urban/suburban EMS system. Over a two-year period, 10 patients were treated with double sequential defibrillation for refractory v fib. This was defined as v fib that persisted "following at least five unsuccessful single shocks, epinephrine administration, and a dose of antiarrhythmic medication." Seven patients had successful cardioversion, and three had ROSC. None, however, survived to hospital discharge.[3]

Summary

Double sequential defibrillation is currently being employed in a number of EMS systems across the United States, including Wake County, N.C.; Fort Worth, Texas; and New Orleans. Even though there isn't a large body of literature surrounding this technique, it's been demonstrated successful in the electrophysiology lab, ED and prehospital settings.

Since access to procainamide-another treatment for refractory v fib-is limited, this may be the only available option when faced with a patient who has failed standard ACLS defibrillation and medication administration. It's an intervention that has little chance to do harm, and it may represent the "hail Mary" pass to a successful ROSC touchdown.

References

1. Chang MS, Inoue H, Kallok MJ, et al. Double and triple sequential shocks reduce ventricular defibrillation threshold in dogs with and without myocardial infarction. J Am Coll Cardiol. 1986;8(6):1393-1405.

2. Hoch DH, Batsford WP, Greenberg SM, et al. Double sequential external shocks for refractory ventricular fibrillation. J Am Coll Cardiol. 1994;23(5):1141-1145.

3. Cabañas JG, Myers JB, Williams JG, et al. Double sequential external defibrillation in out-of-hospital refractory ventricular fibrillation: A report of ten cases. Prehosp Emerg Care. 2015;19(1):126-130.

Appendix D – University of Maryland School of Medicine Educational Pearls - Non-stop VFib? Double-down on the Defib!

UNIVERSITY of MARYLAND
SCHOOL OF MEDICINE

UMEM Educational Pearls

Category: Cardiology

Title: Non-stop VFib? Double-down on the defib!

Keywords: defibrillation, tachydysrhythmia, ventricular fibrillation

Posted: 10/30/2011 by Amal Mattu, M.D .

Today's cardiology pearl provided by EMS guru Dr. Ben Lawner. Consider this one if you are caring for a patient with what appears to be shock-resistant VFib.

An intervention that has its roots in the electrophysiology lab has now gained traction on the front lines of resuscitation: double sequential defibrillation. Prospective studies are currently underway to examine the feasibility of this technique. New Orleans (LA) EMS boasts several anectodal accounts of survival, with neurologically intact recovery, from refractory ventricular fibrillation. The next time you can't stop the fibbing, consider this:

- Apply TWO sets of defibrillator pads to the patient; one in traditional sternum/apex configuration and the other in anterior/posterior configuration
- If ventricular fibrillation persists despite several shocks, coordinate the simultaneous firing of BOTH defibrillators

Some caveats:
This treatment is based upon EP lab data; each MONOPHASIC defibrillator was set at 360J. EMS services in New Orleans and Wake County (NC) have used two biphasic defibrillators, each set a 200J. There is not sufficient data to make any widespread recommendation, but the idea of double sequential defibrillation may be another tool in a limited ACLS bag of tricks for patients who simply cannot come out of V-fib. New Orleans EMS has initiated the double-defib protocol after four shocks, and Wake County's protocol recommends initiation after five. Wake's protocol also recommends firing the defibrillators "as synchronously as possible."

References

DH Hoch, WP Batsford, SM Greenberg, CM McPherson, et al. Double sequential defibrillation for refractory ventricular defibrillation. J. Am Cardiol. 1994;23:1141-45.

Appendix E - A Case Series of Double Sequence Defibrillation.

Prehosp Emerg Care. 2016 Jul-Aug;20(4):550-3. doi: 10.3109/10903127.2015.1128026. Epub 2016 Feb 5.
Merlin MA, Tagore A, Bauter R, Arshad FH.

Abstract

INTRODUCTION:

Double Sequence Defibrillation or Double Simultaneous Defibrillation (DSD) is the use of two defibrillators almost simultaneously at their highest allowed energy setting to treat refractory ventricular fibrillation (RVF). One set of pads is placed in the Anterior-Posterior position and the other set of pads is placed in the Anterior-Lateral Position. Both defibrillation buttons are pressed simultaneously. We sought to determine ROSC and survival rates in a large EMS system when DSD is routinely utilized for RVF.

METHOD:

A retrospective case series was performed of all patients who received DSD from January 1, 2015 to April 30, 2015. During the four month period, we requested physicians to instruct paramedics to use DSD on patients after three refractory episodes of VF. All Advanced Cardiac Life Support (ALS) patients treated by paramedics are discussed via telephone communication with a physician in the system of 100 ALS treated patients per day.

RESULTS:

From January 1, 2015 to April 1, 2015, a total of 7 patients were treated with DSD. The mean age was 62 (Range: 45-78), with mean resuscitation time of 34.3 minutes before first DSD (Range: 23-48). The mean number of single shocks was 5.4 prior to DSD (Range: 3-9), with a mean of 2 DSD shocks delivered. VF converted after DSD in 5 cases (57.1%). Four patients survived to admission (43%). Three patients survived to discharge with no or minimal neurologic disability (28.6%). The mean Cerebral Performance Category Scale was 3.4 with 1 indicating good cerebral performance and 5 indicating Brain Death.

DISCUSSION:

The correct amount of energy in joules for VF remains unknown. In this case series, significant patients converted out of VF. The reason for improved VF conversion may be several factors including additional defibrillation vectors, increased energy, more energy across myocardium, and unknown variables. Additional research is underway to determine if routine DSD will result in improved survival compared to standard defibrillation techniques.

Appendix E - Double Sequential External Defibrillation in Out-of-Hospital Refractory Ventricular Fibrillation: A Report of Ten Cases.

Cabañas JG, Myers JB, Williams JG, De Maio VJ, Bachman MW.

Prehosp Emerg Care. 2015 January-March;19(1):126-130. Epub 2014 Sep 22.

Format : Abstract

Abstract Background

Ventricular fibrillation (VF) is considered the out-of-hospital cardiac arrest (OOHCA) rhythm with the highest likelihood of neurologically intact survival. Unfortunately, there are occasions when VF does not respond to standard defibrillatory shocks. Current American Heart Association (AHA) guidelines acknowledge that the data are insufficient in determining the optimal pad placement, waveform, or energy level that produce the best conversion rates from OOHCA with VF.

Objective

To describe a technique of double sequential external defibrillation (DSED) for cases of refractory VF (RVF) during OOHCA resuscitation. Methods. A retrospective case series was performed in an urban/suburban emergency medical services (EMS) system with advanced life support care and a population of 900,000. Included were all adult OOHCAs having RVF during resuscitation efforts by EMS providers. RVF was defined as persistent VF following at least 5 unsuccessful single shocks, epinephrine administration, and a dose of antiarrhythmic medication. Once the patient was in RVF, EMS personnel applied a second set of pads and utilized a second defibrillator for single defibrillation with the new monitor/pad placement. If VF continued, EMS personnel then utilized the original and second monitor/defibrillator charged to maximum energy, and shocks were delivered from both machines simultaneously. Data were collected from electronic dispatch and patient care reports for descriptive analysis.

Results

From 01/07/2008 to 12/31/2010, a total of 10 patients were treated with DSED. The median age was 76.5 (IQR: 65-82), with median resuscitation time of 51minutes (IQR: 45-62). The median number of single shocks was 6.5 (IQR: 6-11), with a median of 2 (IQR: 1-3) DSED shocks delivered. VF broke after DSED in 7 cases (70%). Only 3 patients (30%) had ROSC in the field, and none survived to discharge.

Conclusion

This case series demonstrates that DSED may be a feasible technique as part of an aggressive treatment plan for RVF in the out-of-hospital setting. In this series, RVF was terminated 70% of the time, but no patient survived to discharge. Further research is needed to better understand the characteristics of and treatment strategies for RVF.