Available online at www.sciencedirect.com

Resuscitation

journal homepage: www.elsevier.com/locate/resuscitation

Editorial

Dual sequential defibrillation: Hold your horses!

Dual sequential defibrillation (DSD) continues to be adopted into clinical practice without any evidence to support its benefits and certainly some suggestion that it may do more harm than good.[1] Does the latest evidence from Cheskes and his research team[2] provide evidence that we should be looking to introduce this technique of last resort?

Approximately 20% of cardiac arrests initially present in a shockable rhythm; usually ventricular fibrillation (VF). Of these, about 20% will remain in VF after 5 shocks, despite standard resuscitation interventions.[3] Not surprisingly, patients in refractory VF have significantly lower rates of survival than patients who respond to standard resuscitation treatments and it is a clinical priority to terminate VF as soon as possible.

Dual sequential defibrillation was introduced on the premise that 'more must be better' and was initially spurred on by a number of case reports that represent no more than publication bias. The term 'dual (or double) sequential defibrillation' refers to a non-standardised technique that has a number of important variations in how it is delivered. In most cases, the initial defibrillation pads are placed in a standard antero-lateral position, according to current guidelines.[4] The second pair is either placed alongside the first, or in an antero-posterior position. The technique of shock delivery also varies between cases. In initial case reports, both defibrillators were discharged at exactly the same time, potentially resulting in overlapping waveforms. This has resulted in at least one case where one defibrillator has been damaged by its counterpart and more recent studies, including that by Cheskes et al. have deliberately introduced a short manual pause between discharge of each defibrillator.

Theoretical reasons as to why dual sequential defibrillation might be more effective in refractory VF include:

1 **Multiple shock vectors** The defibrillation threshold for each cardiac myocyte is lowest when defibrillation takes place along the longitudinal axis of the cell.[5] The use of two vectors, through dual pads, will expose many more myocytes to a defibrillation shock along their longitudinal axis and potentially increase the number of myocytes in which VF is terminated.
2 **Reduced transthoracic impedance** Sequential biphasic shocks lower transthoracic impedance.[6] A second shock may be more successful in therefore delivering a greater current density and therefore improving shock success.
3 **Defibrillation of a critical myocardial mass** Successful defibrillation requires the defibrillation of a critical mass of myocardium. A second pair of defibrillation pads placed in a different anatomical position are likely to have an additive effect to increase the mass of myocardium exposed to a defibrillating current.[7]

The defibrillation energy doses recommended by contemporary guidelines are broadly based on historical animal studies, which showed a clear dose-response effect. Increasing energy levels further was shown to increase both myocardial damage and the risk of death without increasing defibrillation efficacy.[8] In keeping with this historical animal evidence, there is no current clinical evidence that first shock defibrillation efficacy improves by increasing energy to levels higher than the recommended minimum of 150J.[4,9] Consistent with this, a recent retrospective cohort study From the Get With the Guidelines-Resuscitation Registry concluded that compared with 200J, a starting energy of 150J was associated with better survival to discharge (OR 1.19, 95% CI 1.04−1.37) and starting energies of 360J were associated with a worse survival to discharge (OR 0.69, 95% CI 0.56−0.84).[10] Although human studies have not shown harm (raised biomarkers, ECG changes, ejection fraction, arrhythmias etc.) from any biphasic waveform up to 360J, several animal studies have demonstrated the potential for harm with higher energy levels.[4] Taken as a whole, this suggests that currently recommended energy levels are optimal to achieve successful defibrillation without causing harmful myocardial damage.

As the technique of dual sequential defibrillation has become more widespread, case reports have been replaced by relatively small cohort studies, all of which have failed to demonstrate any clear benefit. The largest of these was a study by Beck et al. who compared a total of 310 patients; 71 receiving DSD and 239 receiving conventional defibrillation.[11] ROSC was lower for DSD than standard defibrillation and there were no differences in survival to hospital admission, or survival to hospital discharge (14.3% vs. 20.9%, adjusted OR 0.63 [95% CI: 0.27−1.45]). In a similar study of 279 patients, 50 receiving DSD and 229 receiving conventional defibrillation, Ross et al. found no difference in neurologically intact survival between standard defibrillation and DSD.[12] Consistent with these results, Cheskes et al. in a study of 252 patients, of whom 51 received DSD and 201 received conventional defibrillation, found no difference in VF termination to ROSC between standard defibrillation and DSD.[13] Smaller studies have all also failed to convincingly demonstrate any benefit of DSD compared with conventional defibrillation.[14–17] A recent ILCOR systematic review concluded that based on the evidence presented by these studies, the certainty around the evidence for DSD compared to standard

defibrillation was very low, the results across studies being inconsistent and there being a large degree of potential confounding within each study.[18] Subsequently, ILCOR has suggested against the routine use of dual (double) sequential defibrillation in comparison to a standard defibrillation strategy for refractory VF (weak recommendation, very low certainty of evidence).

In this edition of 'Resuscitation', Cheskes and his team present the results of an eagerly awaited pilot, cluster randomized trial with crossover, conducted in 4 EMS services in Ontario, Canada.[2] Of 152 enrolled patients, 89% received their assigned therapy, which for a pre-hospital cardiac arrest study is a commendable compliance rate. The three-armed approach (standard, vector change and DSD) will produce interesting results as to optimal pad positioning, but inevitably increases the number of patients that will need to be received to achieve adequate power. Return of spontaneous circulation (ROSC) was obtained in 25% of the standard care group, 39% of the vector change group, and 40% of the DSD group. Not surprisingly, fewer patients then arrived at the ED with ROSC, but proportions between the three groups were broadly similar (19% standard care, 25% vector change, and 33% double sequence). Without adequate power and statistical analysis, corrected for intention to treat and other confounding variables if appropriate, the results cannot be interpreted with any meaning. Furthermore, the endpoints in studies of DSD are key to understating the efficacy of this intervention and those presented in the pilot study are only short term. If DSD results in ROSC, but subsequent myocardial stunning results in cardiogenic shock, arrhythmias and death, it is not an effective intervention. In a similar manner to the PARAMEDIC2 adrenaline study, where adrenaline increased ROSC but made little difference to long-term outcome,[19] DSD may potentially achieve the same. As a pilot study, Cheskes et al. have demonstrated the feasibility of a full randomised study,[2] but their pilot results together with all other evidence certainly reinforces the need for a clinical trial that is powered for neurologically-intact survival. Cheskes et al. are to be commended for undertaking this important study and we await with interest their eventual conclusions.

Funding

None.

Conflict of interest

CDD is the ILCOR domain lead for defibrillation, was the lead author of the recent ILCOR systematic review referred to in this editorial,[18] and is a member of the ILCOR ALS writing group.

REFERENCES

1. Deakin CD, Kerber RE. Dual sequential defibrillation: does one plus one equal two? Resuscitation 2016;108:A1–2.
2. Cheskes S, Dorian P, Feldman M, et al. Double sequential external defibrillation for refractory ventricular fibrillation: the DOSE VF pilot randomized controlled trial. Resuscitation 2020;150:178–84.
3. Koster RW, Walker RG, Chapman FW. Recurrent ventricular fibrillation during advanced life support care of patients with prehospital cardiac arrest. Resuscitation 2008;78:252–7.
4. Soar J, Nolan JP, Bottiger BW, et al. European Resuscitation Council Guidelines for Resuscitation 2015: section 3. Adult advanced life support. Resuscitation 2015;95:100–47.
5. Ranjan R, Thakor NV. Electrical stimulation of cardiac myocytes. Ann Biomed Eng 1995;23:812–21.
6. Deakin CD, Ambler JJ, Shaw S. Changes in transthoracic impedance during sequential biphasic defibrillation. Resuscitation 2008;78:141–5.
7. Panescu D, Webster JG, Tompkins WJ, Stratbucker RA. Optimization of cardiac defibrillation by three-dimensional finite element modeling of the human thorax. IEEE Trans Biomed Eng 1995;42:185–92.
8. Babbs CF, Tacker WA, VanVleet JF, Bourland JD, Geddes LA. Therapeutic indices for transchest defibrillator shocks: effective, damaging, and lethal electrical doses. Am Heart J 1980;99:734–8.
9. Morrison LJ, Henry RM, Ku V, Nolan JP, Morley P, Deakin CD. Single-shock defibrillation success in adult cardiac arrest: a systematic review. Resuscitation 2013;84:1480–6.
10. Schneider PM, Liu W, Grunwald GK, et al. Biphasic waveform external defibrillation starting energy and in-hospital cardiac arrest survival: retrospective Cohort Study From the Get With the Guidelines-Resuscitation Registry. J Minneapolis Heart Inst Found 2018;2:7–14.
11. Beck LR, Ostermayer DG, Ponce JN, Srinivasan S, Wang HE. Effectiveness of prehospital dual sequential defibrillation for refractory ventricular fibrillation and ventricular tachycardia cardiac arrest. Prehosp Emerg Care 2019;23:597–602.
12. Ross EM, Redman TT, Harper SA, Mapp JG, Wampler DA, Miramontes DA. Dual defibrillation in out-of-hospital cardiac arrest: a retrospective cohort analysis. Resuscitation 2016;106:14–7.
13. Cheskes S, Wudwud A, Turner L, et al. The impact of double sequential external defibrillation on termination of refractory ventricular fibrillation during out-of-hospital cardiac arrest. Resuscitation 2019;139:275–81.
14. Cabanas JG, Myers JB, Williams JG, De Maio VJ, Bachman MW. Double sequential external defibrillation in out-of-hospital refractory ventricular fibrillation: a report of ten cases. Prehosp Emerg Care 2015;19:126–30.
15. Cortez E, Krebs W, Davis J, Keseg DP, Panchal AR. Use of double sequential external defibrillation for refractory ventricular fibrillation during out-of-hospital cardiac arrest. Resuscitation 2016;108:82–6.
16. Mapp JG, Hans AJ, Darrington AM, et al. Prehospital double sequential defibrillation: a matched case-control study. Acad Emerg Med 2019;26:994–1001.
17. Merlin MA, Tagore A, Bauter R, Arshad FH. A case series of double sequence defibrillation. Prehosp Emerg Care 2016;20:550–3.
18. Deakin CD, Drennan I, Morley PT, Soar J, on behalf of the International Liaison Committee on Resuscitation Advanced Life Support Task Force. Double Sequence Defibrillation. Consensus on Science with Treatment Recommendations [Internet] Brussels, Belgium: International Liaison Committee on Resuscitation (ILCOR) Advanced Life Support Task Force, 2020 January 3. [Available from]: http://ilcor.org.
19. Perkins GD, Ji C, Deakin CD, et al. A randomized trial of epinephrine in out-of-hospital cardiac arrest. N Engl J Med 2018;379:711–21.

Charles D. Deakin
Southampton University Hospital NHS Trust, SO16 6YD, United Kingdom

E-mail address: charles.deakin@nhs.net (C. Deakin).

http://dx.doi.org/10.1016/j.resuscitation.2020.03.001