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WHAT'S NEW IN INTENSIVE CARE

Double sequential external defibrillation for refractory ventricular fibrillation

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Sudden cardiac arrest is the third leading cause of death in industrialized nations, resulting in more than 700,000 deaths in Europe and the United States of America (USA) annually, with nearly one-third attributed to ventricular fibrillation (VF) or pulseless ventricular tachycardia [1]. However, despite multiple defibrillation attempts, almost half of these patients remain in shock refractory VF [2–4]. Further defibrillation without modifying the defibrillation method is usually unsuccessful and survival to hospital discharge decreases rapidly with additional defibrillation attempts [5]. Different approaches have been proposed for treating patients with shock refractory VF. Vector change (VC) defibrillation, the technique of switching defibrillation pads from anterior-lateral to anterior–posterior position, has been proposed as a strategy to defibrillate a portion of the ventricle that may not be completely defibrillated by pads in the standard anterior-lateral position. Double sequential external defibrillation (DSED, also referred to as dual sequential external defibrillation) involves the provision of rapid sequential shocks via two defibrillators with defibrillation pads placed in both planes (anterior-lateral and anterior–posterior, Fig. 1) [6, 7].

Past observational studies describing DSED were limited by the serious risk of bias [8]. The recently published DOSE-VF trial is the first randomized controlled trial directly comparing either DSED or VC defibrillation to a common control group of standard defibrillation for adult patients remaining in refractory VF during out-of-hospital cardiac arrest [9]. It was a cluster randomized trial with crossover conducted in 6 Canadian paramedic services. Patients remaining in VF after treatment with advanced life support and three consecutive standard defibrillation attempts were treated by additional standard defibrillation, DSED or VC defibrillation according to the randomly allocated strategy assigned to the paramedic service. The primary outcome was survival to hospital discharge. Secondary outcomes included VF termination, return of spontaneous circulation, and survival with the good neurologic outcome, defined as a modified Rankin Scale score of ≤ 2 at hospital discharge. A total of 405 patients were enrolled; 136 (33.6%) were allocated to standard defibrillation, 125 (30.9%) to DSED, and 144 (35.6%) to VC defibrillation. Survival to hospital discharge was higher in the DSED (30.4%; relative risk [RR], 2.21; 95% confidence interval [CI], 1.33–3.67) and VC (21.7%; RR 1.71; 95% CI 1.01–2.88) groups compared to standard defibrillation (13.3%). Notably, DSED (RR 2.21; 95% CI 1.26–3.88) but not VC defibrillation was associated with a higher proportion or patients achieving the good neurological outcome (RR 1.48; 95% CI 0.81–2.71) compared to standard defibrillation.

The trial had several strengths compared to previous observational research, including the cluster-crossover design to decrease the potential for contamination between intervention groups, the performance of high-quality cardio-pulmonary resuscitation (CPR) employing both manual and automatic external defibrillation defibrillators, near-complete outcome ascertainment, and the inclusion of patient-centered outcomes. Limitations included a smaller than planned sample size because the data safety monitoring board recommended early stopping due to operational challenges related to coronavirus disease 2019 (COVID-19). Some patients continued to receive standard defibrillation after the third shock despite allocation to the DSED or VC groups due to scene circumstances beyond the paramedics control.

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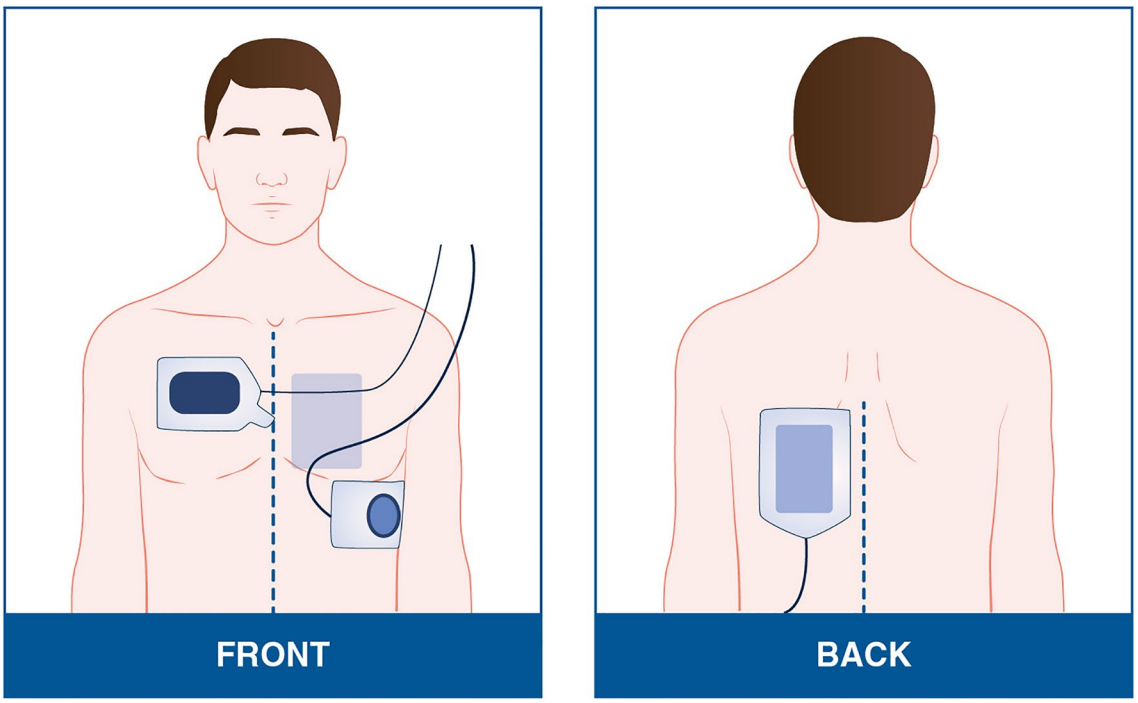

Fig. 1 Pad placement for the different defibrillation strategies. Dark blue defibrillation pads indicate pad placement in the anterior-lateral position. Light-blue defibrillation pads indicate pad placement in the anterior–posterior (VC) position. DSED utilizes both configurations

These patients were considered crossovers to the standard arm if VF was terminated and caused the 'treatment received' analysis to be non-significant. It is possible the treatment effect was overestimated given the small number of events for the primary outcome.

There are several hypotheses to explain why both alternate defibrillation strategies may be effective for treating refractory VF. When defibrillation fails to terminate VF, fibrillation often resumes in the region of the lowest voltage and current gradient in the myocardium [10]. The anatomical location of the left ventricle, a posterior structure, is the region of the heart that is furthest from the direct line between the standard anterior-lateral electrode pads, resulting in the potential for the left ventricle to be inadequately defibrillated. This may be exacerbated by conditions such as left ventricular hypertrophy or dilated cardiomyopathy. VC defibrillation may result in a higher voltage gradient across the posterior aspect of the left ventricle compared to standard anterior-lateral pad positioning, increasing the potential for the defibrillation to fully terminate the arrhythmia. DSED provides the same theoretical benefit as VC defibrillation with the additional influence of increased energy delivered by the second defibrillator shock. It remains uncertain whether the benefit from DSED results from this vector change alone, or if the combination of pads placed in two different vectors provides a more homogenous distribution of current through the myocardium than seen with standard anterior-lateral pad placement. It is possible when using DSED that the instantaneous electrical wavefronts become altered by the first standard shock and are more amenable to successful defibrillation during the second shock than if the first "conditioning shock" had not occurred. Finally, a consistent 10–20% drop in impedance was noted for patients in the trial during the VC defibrillation and during the anterior–posterior DSED shock compared to the impedance measured during the previous failed standard anterior-lateral defibrillation, suggesting that the anterior–posterior shock delivered energy more efficiently than the standard shock.

The DOSE VF trial was conducted in the pre-hospital setting, but we recommend clinicians consider either DSED or VC defibrillation for refractory VF after three failed standard shocks regardless of the location. Use of either strategy should follow a protocolized, choreographed application with a focus on high-quality CPR and rapid shock delivery (see video for DSED and VC choreography). The DSED or VC shock should be provided after the third failed standard defibrillation, and not as a late or 'rescue' treatment following multiple shocks beyond the third defibrillation attempt. While the effect size noted in the trial may make a "DSED first"

strategy appealing for patients presenting in VF, we recommend prioritizing prompt defibrillation using standard pad placement which can successfully terminate VF in more than half of cases [5]. Simultaneous defibrillation with two defibrillators carries a very low theoretical risk of damaging the defibrillators, therefore clinicians should ensure sequential shock delivery when using DSED. Implementation in the hospital setting will require training of cardiac arrest response teams to ensure adherence to this approach and the availability of additional defibrillators and multiple pads on cardiac arrest response carts. We recommend preferential use of DSED for refractory VF based on the results of the trial, but if it is not feasible to access two defibrillators routinely, VC is an appealing alternative.

DSED and VC defibrillation are exciting and innovative strategies that can improve survival for patients presenting with refractory VF. Time will tell if these will be broadly implemented and embraced by paramedics and clinicians.

Supplementary Information
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Data availability statement
The datasets generated and analyzed during the current study are not available at this time.

Declarations

Conflicts of interest
SC has received a speaking honorarium for educational events on CPR quality from Zoll Medical and the Stryker Corporation. SC has received project grant funding from Zoll Medical and the Cardiovascular Network of Canada (CANet) for unrelated research studies. DCS holds operating grants from the Canadian Institute for Health Research. SC is the principal investigator of the DOSE VF RCT and DCS is the senior author of the DOSE VF RCT. No other authors have any conflicts of interest to declare.

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