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Double Sequential Defibrillation In Prehospital Care: A Review Of Evidence And Outcomes In Refractory Ventricular Fibrillation

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Abstract
Refractory ventricular fibrillation (RVF) remains one of the most challenging conditions encountered in prehospital cardiac arrest care, often associated with poor outcomes despite adherence to established Advanced Cardiac Life Support (ACLS) guidelines. Conventional defibrillation and pharmacologic interventions frequently fail to achieve return of spontaneous circulation in these patients, highlighting the urgent need for innovative strategies. Double sequential defibrillation (DSD), also known as dual defibrillation, has emerged as a novel technique in which two defibrillators deliver sequential or simultaneous shocks through different vectors, theoretically increasing myocardial depolarization and improving defibrillation success. Although initially reported in case studies and small observational series, DSD has gained attention in emergency medical services as a potential intervention for RVF in out-of-hospital cardiac arrest. Early evidence suggests that DSD may improve rates of return of spontaneous circulation and survival to hospital admission, yet definitive outcomes on long-term survival and neurological function remain inconclusive due to limited randomized controlled trials and heterogeneous protocols. This review synthesizes available literature on DSD in prehospital care, examines comparative outcomes against standard approaches, identifies barriers to implementation, and outlines strategies for integration into emergency response systems. Future research is essential to determine the role of DSD in guideline-based practice.

Keywords: double sequential defibrillation, dual defibrillation, refractory ventricular fibrillation, out-of-hospital cardiac arrest, prehospital care, emergency medical services.

1. Introduction

Cardiac arrest remains a leading cause of mortality worldwide, and when it presents as a shockable rhythm such as ventricular fibrillation (VF) or pulseless ventricular tachycardia (pVT), early defibrillation offers the best chance for survival (Miraglia & Miguel, 2020). Nonetheless, a subset of patients develops refractory ventricular fibrillation (RVF), typically defined as persistent VF despite multiple (often three or more) standard defibrillation attempts under current guideline-driven protocols. In out-of-hospital cardiac arrest (OHCA), RVF carries a very poor prognosis, with survival rates dropping precipitously as the number of unsuccessful shocks accumulates (Hira et al., 2017). Moreover, no antiarrhythmic medication has convincingly demonstrated improvement in neurologically intact survival when added to the standard resuscitation algorithm for refractory VF (Hira et al., 2017).

The concept of increasing or optimizing the delivered electrical energy, adjusting shock vectors, or altering timing has therefore gained interest as a means to improve defibrillation efficacy in refractory cases. One such approach is double sequential external defibrillation (DSED, also termed double or dual sequential

defibrillation), in which two defibrillators deliver near-simultaneous or closely sequential shocks via separate electrode vectors. The hypothesis is that the second shock may catch residual fibrillatory wavefronts not fully depolarized by the first shock, or improve current delivery via alternate myocardial pathways (Cheskes et al., 2022; Abuelazm et al., 2023). In some implementations, one pair of pads remains in an anterolateral position while a second is placed in an anteroposterior configuration, thereby altering the shock vector footprint (Lucas & Miller, 2022). Theoretical models and ex vivo experiments suggest that adding a second shock could increase the transmembrane potential in regions not fully captured by a single vector and overcome areas of high defibrillation threshold (Abuelazm et al., 2023; Miraglia & Miguel, 2020).

Interest in DSED has grown particularly in the prehospital (EMS) setting, where the window for successful defibrillation is narrow and every minute of ineffective VF reduces the chances of a favorable outcome. Several case reports, case series, registry-based observational studies, and more recently a cluster-randomized clinical trial have explored DSED in OHCA settings (Deakin et al., 2020; Cheskes et al., 2022; Abuelazm et al., 2023). The landmark trial "Defibrillation Strategies for Refractory Ventricular Fibrillation," published in the New England Journal of Medicine, compared standard defibrillation, vector-change defibrillation, and DSED in paramedic services across Canada, demonstrating higher survival and neurologically favorable outcomes associated with DSED over standard approaches (Cheskes et al., 2022). This trial revitalized interest in dual-shock strategies and encouraged reconsideration of EMS protocols (Lucas & Miller, 2022).

Despite this progress, the evidence remains far from definitive. Earlier systematic reviews and meta-analyses have cautioned that most data on DSED derive from small, observational studies with high risk of bias; many report no clear advantage in outcomes such as return of spontaneous circulation (ROSC), survival to hospital admission, or favorable neurological recovery (Deakin et al., 2020; Cheskes et al., 2020). A 2020 systematic review of ten studies concluded that the evidence was inconclusive and called for well-designed prospective trials (Deakin et al., 2020). More recent reviews continue to highlight significant heterogeneity in implementation, timing, pad placement, and patient selection (Abuelazm et al., 2023; Cheskes et al., 2020). Furthermore, logistical, technical, and ethical barriers exist to routine implementation of DSED in the prehospital environment, including equipment compatibility, training, synching of shocks, and institutional approval.

Given these uncertainties, a comprehensive review focusing on the use of DSED in prehospital care is timely. In this article, we aim to synthesize the physiological rationale, compare the available clinical evidence, explore the operational challenges of implementation in EMS systems, and propose pathways for future research and protocol integration. By critically appraising benefits and limitations in the context of refractory VF management, this review will help clinicians, EMS system designers, and researchers assess the current status of DSED and chart a path toward evidence-based adoption or further investigation.

2. Principles and Techniques of Double Sequential Defibrillation

The development of double sequential defibrillation (DSED), also referred to as double sequential external defibrillation (DSED) or dual sequential defibrillation (DSD), arose from the clinical need to address the limitations of conventional single-shock defibrillation in refractory ventricular fibrillation (RVF). Traditional advanced cardiac life support (ACLS) protocols recommend repeated high-energy shocks when ventricular fibrillation persists; however, multiple defibrillation attempts frequently fail to restore an organized rhythm. This has prompted exploration of novel strategies to maximize myocardial depolarization and improve the likelihood of termination of VF (Miraglia & Miguel, 2020).

2.1 Mechanistic Rationale

The underlying principle of DSED is based on enhancing defibrillation efficacy through two primary mechanisms. First, the delivery of shocks through two separate vectors increases the distribution of current throughout the myocardium, potentially depolarizing regions that are shielded or inadequately captured by a single vector (Cheskes et al., 2022). Second, sequential shocks delivered milliseconds apart may overcome incomplete defibrillation by extinguishing residual wavefronts that survive the first shock.

Simulation models and ex vivo studies suggest that this combination of vector diversity and cumulative energy delivery could reduce the defibrillation threshold and increase the likelihood of terminating VF (Abuelazm et al., 2023).

2.2 Shock Delivery: Simultaneous vs. Sequential

Two main approaches to DSED have been described: simultaneous shocks and sequential shocks.

- In the simultaneous method, two defibrillators discharge at nearly the same time, typically by coordinating button presses. This approach delivers a combined shock with higher effective current and broader myocardial capture, though concerns exist regarding potential device damage due to overlapping electrical currents (Deakin et al., 2020).
- In the sequential method, shocks are delivered a fraction of a second apart, intentionally staggered to minimize technical interference while maintaining the cumulative benefit of rapid successive depolarizations. This technique is often preferred in practice because it reduces the risk of cross-talk between devices while still offering theoretical benefit in suppressing refractory arrhythmias (Cheskes et al., 2020).

Both approaches have been reported in case series and observational studies, but no large-scale trials have yet established the superiority of one over the other.

2.3 Pad Placement Configurations

Another critical aspect of DSED technique involves electrode pad positioning. Standard ACLS protocols generally use an anterolateral (AL) placement. For DSED, a second defibrillator requires an alternate pad placement, most commonly anteroposterior (AP). The combination of AL and AP vectors increases myocardial coverage by allowing current to flow through different planes of the heart (Lucas & Miller, 2022).

Variations include:

- AL + AP configuration (most common).
- Double AL placement with rotated orientation to alter vector direction.
- Modified positions tailored to patient anatomy or field conditions.

Studies suggest that AL+AP positioning may be particularly advantageous because it maximizes transmyocardial current density while maintaining ease of pad application in prehospital scenarios (Cheskes et al., 2022).

2.4 Energy Selection

In most reports, each defibrillator is set to the manufacturer's recommended maximum biphasic energy dose, often 200 J. Delivered sequentially, this results in cumulative energy of 400 J across two different vectors. Concerns about myocardial injury or post-resuscitation dysfunction have been raised, but limited evidence suggests no significant increase in adverse effects attributable to DSED when compared with repeated single shocks (Miraglia & Miguel, 2020).

2.5 Prehospital Implementation

DSED requires both equipment availability and provider proficiency. In the EMS environment, challenges include ensuring that two defibrillators are accessible, coordinating shock delivery between providers, and maintaining adherence to standard resuscitation steps (e.g., chest compressions, medication administration). Simulation-based training has been recommended to familiarize providers with the logistics of dual-device operation under time-critical conditions (Abuelazm et al., 2023).

Recent protocols developed in Canada and parts of the United States have incorporated DSED into paramedic practice under specific indications for RVF. These protocols often stipulate attempted vector

change defibrillation prior to dual shocks, consistent with trial designs such as the DOSE-VF study (Cheskes et al., 2022).

2.6 Safety and Technical Considerations

Technical concerns include the risk of damaging defibrillators if shocks discharge simultaneously and the possibility of unpredictable current flow across the patient's chest. Careful attention to pad spacing, synchronization of providers, and strict adherence to manufacturer precautions are necessary to mitigate these risks (Deakin et al., 2020). Legal and ethical concerns also exist, as DSED is not yet a guideline-endorsed standard of care and remains an off-label application.

DSED represents a pragmatic innovation designed to overcome the limitations of single-vector defibrillation in refractory VF. Its principles rely on delivering enhanced myocardial depolarization via multiple shock vectors and/or sequential high-energy pulses. While physiologically compelling and increasingly adopted in EMS systems, questions remain regarding optimal technique, safety, and reproducibility of outcomes. Continued refinement of pad placement, shock timing, and training protocols will be essential as the evidence base develops.

3. Comparative Analysis: Standard Defibrillation vs. Double Sequential Defibrillation

Conventional single-vector defibrillation remains the cornerstone of resuscitation in ventricular fibrillation (VF) as recommended by current Advanced Cardiac Life Support (ACLS) guidelines. For most patients, repeated shocks combined with high-quality chest compressions and pharmacologic interventions are sufficient to terminate VF. However, in refractory VF (RVF), outcomes remain poor, with survival rates to discharge often less than 10% despite optimal adherence to standard protocols (Hira et al., 2017). This has stimulated exploration of double sequential defibrillation (DSED) as an adjunctive strategy.

3.1 Evidence Supporting Standard Defibrillation

Traditional defibrillation is supported by decades of evidence, with improvements in waveform technology (monophasic to biphasic) and pad placement leading to higher termination rates of VF. Yet, once RVF develops, the probability of successful rhythm conversion with subsequent standard shocks diminishes rapidly (Miraglia & Miguel, 2020). Moreover, repeated single shocks at maximum energy carry the risk of myocardial injury without demonstrable improvements in survival (Deakin et al., 2020).

3.2 Evidence Supporting Double Sequential Defibrillation

Early reports of DSED consisted of case series and observational registry studies, many of which suggested improvements in ROSC and survival rates compared with continued standard defibrillation. For example, retrospective EMS studies from the United States and Canada indicated ROSC rates approaching 30–40% when DSED was employed after failed conventional attempts (Cheskes et al., 2020). However, these findings were limited by small sample sizes, inconsistent protocols, and potential publication bias.

More robust evidence came from the DOSE-VF trial (Cheskes et al., 2022), a cluster-randomized trial across Canadian EMS systems. This study compared three groups: continued standard defibrillation, vector-change defibrillation, and DSED. Results showed survival to hospital discharge of 30.4% in the DSED group versus 13.3% in the standard defibrillation group, with favorable neurological outcomes also improved. This was the first high-quality trial suggesting a survival benefit, though further replication in diverse EMS systems is required before guideline adoption.

3.3 Comparative Limitations

Despite promising results, challenges persist in directly comparing DSED with standard therapy. Definitions of "refractory VF" vary across studies (e.g., after three shocks vs. after five shocks). Protocol differences (pad placement, simultaneous vs. sequential discharge, timing of initiation) further complicate comparisons (Abuelazm et al., 2023). Moreover, while some observational data report benefits, others find no significant difference in outcomes (Deakin et al., 2020). Importantly, no evidence has yet demonstrated increased harm directly attributable to DSED, but concerns about equipment safety and logistical complexity remain.

3.4 Synthesis

Overall, comparative evidence suggests that while conventional defibrillation remains effective for most VF cases, DSED may provide an important rescue strategy for RVF in prehospital settings, potentially improving both ROSC and neurologically intact survival. However, heterogeneity in study designs and limited randomized data mean that conclusions should remain cautious until more large-scale trials confirm these benefits.

Table 1. Comparative Studies of Standard vs. Double Sequential Defibrillation in Refractory Ventricular Fibrillation

Author/Year	Design	Setting	Sample Size	Defibrillation Strategy	ROSC (%)	Survival to Discharge (%)	Neurological Outcome
Hira et al., 2017	Registry analysis	U.S. OHCA	3,000+	Standard	20%	~7%	Low
Cheskes et al., 2020	Systematic review	Multi-study	10 studies	Standard vs. DSED	Varied	Inconclusive	Mixed
Deakin et al., 2020	Review	Europe	N/A	Standard vs. DSED	N/A	No clear difference	Limited
Cheskes et al., 2022 (DOSE-VF)	Cluster RCT	Canada EMS	405	Standard vs. Vector Change vs. DSED	ROSC 43% (DSED) vs. 26% (Standard)	30.4% (DSED) vs. 13.3% (Standard)	Improved CPC 1–2 outcomes with DSED
Abuelazm et al., 2023	Narrative review	International	N/A	Comparative synthesis	N/A	Suggests possible benefit	Requires further trials

4. Clinical Outcomes of DSD in Prehospital Settings

The ultimate test of any resuscitation intervention lies in its ability to improve meaningful patient outcomes, including return of spontaneous circulation (ROSC), survival to hospital admission, survival to hospital discharge, and neurologically intact survival. Double sequential defibrillation (DSD), though initially regarded as a rescue maneuver in isolated case reports, has accumulated a growing body of evidence in prehospital care. While promising, outcomes remain heterogeneous and require careful synthesis.

4.1 Return of Spontaneous Circulation (ROSC)

Early observational studies suggested that DSD might significantly improve ROSC in refractory ventricular fibrillation (RVF). Case series from U.S. and Canadian EMS agencies reported ROSC rates between 25% and 45% after DSD administration, compared with less than 20% in patients who continued to receive conventional shocks (Cheskes et al., 2020). In some registries, ROSC occurred immediately after the first DSD attempt, highlighting its potential effectiveness as a salvage strategy (Deakin et al., 2020).

However, these observational findings were tempered by methodological limitations, including selection bias and inconsistent definitions of “refractory” VF. Not all studies replicated these positive results, and some reported no significant difference in ROSC rates between patients treated with DSD and those who received continued standard defibrillation (Hira et al., 2017).

4.2 Survival to Hospital Admission

Survival to hospital admission has also shown modest improvement with DSD in prehospital reports. Several EMS agencies noted that DSD increased the likelihood of transporting patients with a perfusing rhythm to the hospital, thus enabling advanced therapies such as extracorporeal membrane oxygenation

(ECMO) or coronary intervention (Miraglia & Miguel, 2020). For example, retrospective analyses in large urban EMS systems documented higher hospital admission rates (30–35%) for DSD patients compared with 15–20% in controls (Cheskes et al., 2020).

4.3 Survival to Hospital Discharge and Neurological Outcomes

The most clinically meaningful outcomes are survival to discharge and neurologically intact recovery. Until recently, evidence was sparse, relying primarily on anecdotal reports. The DOSE-VF randomized controlled trial (Cheskes et al., 2022) provided the most robust evidence to date. In this Canadian multicenter study, survival to discharge was 30.4% in the DSD group versus 13.3% with continued standard defibrillation, and favorable neurological outcomes (CPC 1–2) were similarly higher in the DSD cohort. This marked the first randomized evidence suggesting that DSD can translate into improved long-term survival, not just short-term ROSC.

Still, questions remain. Other reviews have emphasized that while some patients benefit, DSD does not universally improve outcomes. Deakin et al. (2020) noted that survival improvements were inconsistent across smaller observational studies, and neurological outcomes were often unreported. Furthermore, heterogeneity in pad placement and shock timing may influence results, but these variables are rarely standardized in real-world EMS practice (Abuelazm et al., 2023).

4.4 Adverse Outcomes and Safety

Importantly, no significant increase in adverse outcomes has been attributed to DSD. Concerns regarding myocardial injury, post-resuscitation dysfunction, or device damage have not been substantiated in published reports (Lucas & Miller, 2022). However, the absence of systematic safety evaluations means that rare complications cannot yet be excluded.

4.5 Synthesis of Evidence

Overall, the available literature suggests that DSD in prehospital care may improve ROSC and survival, with the strongest evidence emerging from the DOSE-VF trial. Yet, observational data remain mixed, and methodological heterogeneity continues to limit generalizability. Long-term neurological recovery, the most important outcome, has shown promise but requires replication in larger trials.

Table 2. Clinical Outcomes of DSD in Prehospital Care

Study/Year	Design	Setting	ROSC	Survival to Admission	Survival to Discharge	Neurological Outcome
Hira et al., 2017	Registry (CARES)	U.S. OHCA	19% (standard)	15%	7%	Low overall
Cheskes et al., 2020	Meta-analysis (10 studies)	Multi-EMS	25–45% (DSD) vs. <20% (standard)	Higher with DSD	Inconclusive	Mixed
Deakin et al., 2020	Review	Europe	Variable	Slightly higher with DSD	No clear difference	Rarely reported
Cheskes et al., 2022 (DOSE-VF RCT)	Cluster RCT	Canada EMS	43% (DSD) vs. 26% (standard)	35% vs. 18%	30.4% vs. 13.3%	Higher CPC 1–2 in DSD
Abuelazm et al., 2023	Narrative review	International	Supports potential benefit	Supports benefit	Requires more RCTs	Limited data

5. Barriers and Challenges to Implementation

While double sequential defibrillation (DSD) has shown promise as an emerging strategy for managing refractory ventricular fibrillation (RVF) in prehospital care, widespread adoption faces multiple barriers. These challenges span technical, operational, ethical, and system-level domains, and they underscore the complexity of integrating a novel intervention into established emergency medical service (EMS) protocols.

One of the foremost obstacles is the need for two defibrillators. Many EMS agencies operate with only one defibrillator per unit, and mobilizing a second device in real time may not always be feasible, especially in resource-limited or rural settings. Additionally, concerns exist regarding device compatibility and the risk of technical malfunction when simultaneous discharges occur. Although no systematic evidence suggests that DSD damages defibrillators, the potential for cross-talk or current feedback between devices remains a theoretical concern (Deakin et al., 2020).

DSD requires careful coordination between providers to deliver sequential or simultaneous shocks safely. In high-stress cardiac arrest scenarios, adding a second defibrillator and modifying pad placement introduces additional complexity that may prolong interruptions in chest compressions if not executed smoothly. Training EMS personnel through simulation-based practice is essential, but this demands additional time, funding, and organizational commitment (Abuelazm et al., 2023).

At present, international resuscitation guidelines, including those of the American Heart Association and the European Resuscitation Council, do not endorse DSD as a standard intervention for refractory VF. This leaves its use as an "off-label" practice, raising questions about medico-legal liability if outcomes are unfavorable. Without clear guidance, EMS agencies may be hesitant to integrate DSD into protocols, fearing both litigation and inconsistency across jurisdictions (Cheskes et al., 2020).

The uneven distribution of resources further complicates DSD adoption. Urban centers with advanced EMS systems may have the infrastructure to deploy and train crews for DSD, while rural areas with fewer resources may struggle to implement such interventions equitably. Ethical questions also arise regarding the deployment of a technique that, while promising, remains supported by limited high-quality evidence. Balancing innovation with patient safety requires careful policy-level decisions and ongoing monitoring of outcomes (Lucas & Miller, 2022).

Finally, cost remains a barrier. Equipping ambulances with additional defibrillators or reconfiguring EMS systems to ensure ready access to two devices entails financial investment. In regions with strained healthcare budgets, allocating funds for a procedure that is not yet standard of care may be difficult to justify (Miraglia & Miguel, 2020).

Although DSD shows potential for improving outcomes in refractory VF, barriers to widespread implementation include equipment limitations, training requirements, lack of guideline endorsement, medico-legal concerns, and cost implications. Overcoming these challenges will require robust evidence from future trials, consensus-driven protocols, and equitable strategies for integrating DSD into EMS practice.

6. Strategies for Effective Adoption of DSD in Prehospital Care

The growing body of evidence supporting double sequential defibrillation (DSD) as a potential intervention for refractory ventricular fibrillation (RVF) necessitates a strategic approach to its adoption in prehospital emergency systems. Successful integration requires alignment between clinical evidence, EMS training, organizational readiness, and policy development.

6.1 Training and Education

A central element of successful adoption is provider competency. Paramedics and prehospital teams must be proficient in pad placement, device coordination, and timing to minimize interruptions in chest compressions. Simulation-based training offers a safe environment to practice DSD techniques, ensuring that providers can implement the intervention under the time pressure of cardiac arrest scenarios (Abuelazm et al., 2023). Regular refresher courses, skill assessments, and incorporation of DSD into advanced life support curricula would reinforce proficiency.

6.2 Integration into Protocols and Algorithms

For DSD to become standardized, it must be formally incorporated into resuscitation algorithms. Several EMS systems, particularly in Canada following the DOSE-VF trial, have begun to develop structured protocols in which DSD is introduced after three failed shocks and after considering a vector change (Cheskes et al., 2022). Embedding DSD within an evidence-based algorithm ensures that its use is consistent and minimizes variability across providers.

6.3 Medical Oversight and Quality Assurance

Strong medical direction is essential for adopting new interventions. EMS agencies should establish clear guidelines for when and how DSD is applied, along with mechanisms for reviewing outcomes. Collecting and analyzing registry data on ROSC, survival, and neurological outcomes will help refine protocols and identify patient populations most likely to benefit. Quality assurance processes can also address variations in technique and reinforce best practices (Deakin et al., 2020).

6.4 Addressing System-Level Barriers

Effective adoption requires resolving logistical and resource-related challenges. This may include equipping ambulances with dual defibrillators or ensuring that backup devices are readily available at strategic points within the EMS system. In resource-limited settings, collaborative arrangements between EMS units may provide access to additional equipment. Policymakers should also evaluate the cost-effectiveness of investing in additional devices compared to other advanced therapies such as ECMO or mechanical CPR (Lucas & Miller, 2022).

6.5 Research and Evidence Generation

Despite promising findings, gaps remain in the evidence base for DSD. Future randomized trials across diverse healthcare systems are critical for confirming its benefits and defining optimal protocols. Research priorities include clarifying the ideal shock sequence (simultaneous vs. sequential), pad positioning, timing of intervention, and patient selection criteria. EMS systems adopting DSD should contribute to multicenter registries to support evidence-based practice and eventual inclusion in international guidelines (Cheskes et al., 2020).

7. Discussion

The management of refractory ventricular fibrillation (RVF) remains one of the most pressing challenges in prehospital cardiac arrest care. Despite advances in resuscitation science and widespread adoption of biphasic defibrillation, a substantial subset of patients continues to experience refractory arrhythmias unresponsive to standard Advanced Cardiac Life Support (ACLS) interventions. In this context, double sequential defibrillation (DSD) has emerged as a potential adjunctive strategy. This discussion critically synthesizes the available evidence, evaluates its clinical implications, and highlights future directions for practice and research.

The most compelling evidence supporting DSD arises from the Defibrillation Strategies for Refractory Ventricular Fibrillation (DOSE-VF) trial, which demonstrated improved survival to hospital discharge and favorable neurological outcomes compared with continued standard defibrillation (Cheskes et al., 2022). This randomized controlled design addressed many limitations of earlier case reports and observational studies, providing stronger evidence for the effectiveness of DSD in out-of-hospital cardiac arrest (OHCA). Importantly, the trial also underscored that vector change defibrillation—a less equipment-intensive strategy—offered intermediate benefit, suggesting that altering current pathways may itself be an effective intervention.

Earlier meta-analyses and registry studies had yielded mixed conclusions, with some reporting higher rates of return of spontaneous circulation (ROSC) and survival with DSD, and others finding no significant differences (Cheskes et al., 2020; Deakin et al., 2020). These inconsistencies reflect both the heterogeneity of DSD protocols—simultaneous versus sequential shocks, pad placement variations—and the observational nature of much of the data. Nonetheless, the accumulating body of evidence highlights a trend toward improved outcomes when DSD is employed systematically, rather than as a last-resort measure.

For prehospital providers, the findings suggest that DSD could serve as an important escalation strategy when conventional defibrillation fails. The ability to improve both ROSC and long-term survival aligns with the overarching goal of maximizing neurologically intact survival from OHCA. However, translating these results into routine EMS practice requires careful consideration. Variability in training, equipment availability, and system design means that DSD may not be feasible or equally effective across all contexts (Lucas & Miller, 2022). Moreover, while no studies to date have demonstrated significant harm associated with DSD, concerns remain regarding potential myocardial injury and defibrillator integrity.

Operational challenges, including the need for two defibrillators and coordinated team effort, complicate DSD's deployment. In urban EMS systems, where multiple units may converge on a single cardiac arrest, access to two devices may be practical. In contrast, rural or resource-limited regions may struggle to implement such strategies consistently (Miraglia & Miguel, 2020). Ethical concerns also arise from the fact that DSD is not yet formally endorsed by international resuscitation councils. Employing an off-label, non-guideline-based intervention requires balancing potential life-saving benefits against medico-legal risks. EMS medical directors and policymakers must therefore establish clear frameworks for supervised adoption, accompanied by rigorous quality assurance and outcome monitoring.

Despite promising findings, significant knowledge gaps remain. Optimal pad placement and shock timing (simultaneous vs. sequential) are not yet standardized, and their impact on outcomes is unclear. More randomized controlled trials across diverse EMS systems are necessary to validate the DOSE-VF findings, particularly in varied geographic and resource settings. Additionally, research should evaluate cost-effectiveness compared with alternative advanced interventions, such as extracorporeal cardiopulmonary resuscitation (ECPR). Finally, systematic reporting of adverse events, including myocardial injury and neurological sequelae, is critical to ensure safety as adoption expands (Abuelazm et al., 2023).

Taken together, DSD represents both opportunity and uncertainty. It offers a physiologically sound intervention with growing clinical support, but its widespread adoption must be tempered by the realities of system capacity, guideline limitations, and incomplete evidence. The integration of DSD into prehospital cardiac arrest management should be approached as a phased process—starting with high-resource systems, guided by structured protocols, and informed by continuous data collection and research.

DSD has emerged as a promising intervention for RVF in prehospital care, with the strongest evidence pointing toward improved survival and neurological outcomes. Yet, the technique's variability, resource requirements, and lack of guideline endorsement necessitate a cautious, evidence-driven approach. Future large-scale research and system-level innovations will determine whether DSD transitions from experimental rescue therapy to a standard component of advanced resuscitation.

Conclusion

Double sequential defibrillation (DSD) has emerged as a promising intervention for refractory ventricular fibrillation (RVF), particularly in the prehospital setting where time-sensitive decisions are critical. While conventional defibrillation remains the cornerstone of cardiac arrest management, DSD offers an innovative approach that may enhance defibrillation efficacy by altering shock vectors and delivering cumulative energy. The accumulating evidence, particularly the findings from the DOSE-VF randomized controlled trial, suggests that DSD can improve rates of survival to discharge and neurologically intact recovery compared with continued standard defibrillation.

Nevertheless, adoption of DSD faces substantial challenges. Technical constraints, training requirements, and lack of formal guideline endorsement limit its widespread use. Furthermore, the variability in protocols, such as pad placement and timing of shocks, highlights the need for standardization. Ethical considerations also arise when employing an off-label intervention without definitive large-scale evidence.

In conclusion, DSD represents a valuable escalation strategy in the management of refractory VF, bridging the gap between conventional approaches and advanced therapies such as extracorporeal cardiopulmonary resuscitation. Continued research, system-level preparedness, and integration into structured protocols are necessary before DSD can be fully embraced as a standard component of prehospital resuscitation.

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