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Defibrillation Vector Change in CPR A Systematic Review

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Abstract

Cardiopulmonary resuscitation (CPR) and early defibrillation are essential for managing cardiac arrest. Defibrillation, which interrupts chaotic myocardial electrical activity, has traditionally been performed using an automated external defibrillator (AED) with pads in the anterolateral position. However, in cases of refractory ventricular fibrillation (VF), the effectiveness of this technique may decrease, leading to the exploration of alternatives such as defibrillation vector change. This strategy aims to improve shock efficacy by redistributing the electric field and promoting synchronized myocardial depolarization.

This study aims to analyze the scientific evidence on the impact of defibrillation vector change on rhythm conversion, return of spontaneous circulation (ROSC), and survival in patients with cardiac arrest. A systematic review with a meta-analysis of studies published between 2020 and 2025 was conducted, including randomized clinical trials and observational studies on defibrillation pad positioning.

The results indicate that both defibrillation vector change and double sequential external defibrillation (DSED) increase the rate of rhythm conversion and ROSC compared to standard defibrillation. However, the impact on long-term survival remains uncertain. Some studies suggest a slight improvement in survival with DSED, but no statistically significant difference is observed.

The discussion highlights that DSED and defibrillation vector change may be effective strategies for improving rhythm conversion and ROSC. However, their impact on long-term survival is still unclear, and further studies are needed to determine their definitive efficacy. Additionally, the implementation of these techniques requires additional training and standardization of protocols in both prehospital and hospital settings.

Keywords: Cardiopulmonary resuscitation, Defibrillation, Ventricular fibrillation, Double sequential external defibrillation, Return of spontaneous circulation, Survival, Research design, Meta analysis, Cardiopulmonary arrest, Defibrillation vector change in CPR, Defibrillation pad positioning

Introduction

Cardiopulmonary resuscitation (CPR) and early defibrillation are fundamental pillars in managing both out-of-hospital and in-hospital cardiac arrest. Defibrillation aims to interrupt chaotic electrical activity in the myocardium, allowing the restoration of an organized rhythm. Traditionally, automated external defibrillator (AED) pads are placed in the anterolateral position due to their proven efficacy and ease of application in emergency situations.[1] However, in some cases of refractory ventricular fibrillation (VF), repeated shocks in the same position may be ineffective, leading to the exploration of alternatives such as defibrillation vector change.

The defibrillation vector is defined as the trajectory of the electric field generated between the AED pads through the myocardium. Its effectiveness depends on multiple factors, including pad positioning, thoracic impedance, and current direction relative to cardiac anatomy.[2] The underlying hypothesis is that vector change may enhance shock efficacy by redistributing the electric field and facilitating synchronized depolarization of a larger myocardial area.

Various strategies have been evaluated in recent years:

- Changing pad positioning (from anterolateral to anteroposterior or biaxillary).
- Using double sequential external defibrillation (DSED), in which two defibrillators deliver nearly simultaneous shocks from different vectors.

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- Optimizing defibrillation based on thoracic impedance analysis to adjust shock location based on patient characteristics.[3]

Recent clinical trials have observed that vector change after several failed defibrillation attempts may increase the rate of return of spontaneous circulation (ROSC), but its impact on long-term survival remains debated. Some studies suggest that modifying electrode positioning improves shock penetration into the myocardium and reduces electrical fatigue along a single trajectory, while others argue that the advantage is minimal and that early defibrillation, regardless of the initial vector used, is the key factor.

Additionally, computational models and advanced medical imaging simulations have enabled analysis of how electric field distribution varies depending on electrode position and individual patient characteristics. This opens the possibility for a more personalized approach to defibrillation, where vector change decisions are based on objective data rather than a general rule applied to all cases.[4]

Objective

To analyze the available scientific evidence on defibrillation vector change in cardiopulmonary resuscitation (CPR), evaluating its impact on the efficacy of conversion to organized cardiac rhythms, return of spontaneous circulation, and survival rates in patients with cardiac arrest.

Materials and Methods

Study design

This study is a systematic review with a meta-analysis of scientific literature available between 2020 and 2025. Its objective is to analyze the impact of defibrillation vector changes on the effectiveness of cardiopulmonary resuscitation (CPR). This review included experimental and observational studies that address the positioning of defibrillation pads and their effects on the conversion of shockable rhythms, return of spontaneous circulation (ROSC), and survival.

Population and sample

The study population includes adult patients (≥18 years) who have experienced cardiac arrest with shockable rhythms, specifically ventricular fibrillation (VF) or pulseless ventricular tachycardia (pVT).

The review included studies with various sample sizes, ranging from randomized clinical trials to observational cohort studies. No sample size restriction was applied, as the goal was to integrate as much relevant evidence as possible from the last five years.

Inclusion criteria

The following inclusion criteria were applied:

- **Study type:** Randomized clinical trials, large cohort observational studies, systematic reviews, and meta-analyses published between 2020 and 2025.
- **Population:** Adult patients with cardiac arrest and shockable rhythms (VF or pVT).
- **Intervention:** Studies investigating defibrillation vector changes, including defibrillation pad positioning or techniques such as double sequential external defibrillation (DSED).
- **Outcomes:** Reports on efficacy in rhythm conversion, ROSC, and short- and long-term survival.

Exclusion criteria

The following exclusion criteria were established:

- **Animal models:** Studies conducted on non-human models without direct clinical correlation.
- **Individual case reports:** Isolated case reports or low-evidence studies, such as uncontrolled case series.
- **Lack of comparison:** Studies that do not include a control group or do not compare different defibrillation positions.
- **Unrelated interventions:** Studies that do not specifically evaluate defibrillation vector changes in the context of CPR.

Variables

The main variables considered in this review were:

- **Dependent variables:**
  - **Efficacy in rhythm conversion:** Proportion of patients who successfully converted to organized rhythms, such as sinus rhythm or organized electrical activity.
  - **Return of spontaneous circulation (ROSC):** Percentage of patients who achieved ROSC after defibrillation.
  - **Long-term survival:** Survival rate at 30 days or beyond after CPR.
- **Independent variables:**
  - **Defibrillation pad positioning:** Traditional positioning versus vector change or alternative techniques such as double sequential external defibrillation.
  - **Number of defibrillation attempts:** Total number of attempts required to achieve conversion to an organized rhythm.
  - **Time to first defibrillation:** Time between patient collapse and first defibrillation.

Measurement instruments and data collection

The following instruments were used for data collection:

- **Bibliographic databases:** PubMed, Scopus, Cochrane Library, and Web of Science, using search terms such as "Defibrillation vector change in CPR," "Defibrillation pad positioning," and "Double sequential external defibrillation."
- **Data extraction:** Information was extracted using a standardized data collection sheet, including study title, year of publication, study type, number of participants, intervention characteristics (pad positioning and defibrillation technique used), and results in terms of rhythm conversion, ROSC, and survival. Data collection was performed independently by two reviewers, with discrepancies resolved through consensus or by consulting a third reviewer.

Quality assessment of the systematic review

To assess the quality and risk of bias of the included studies, the Cochrane Risk of Bias tool was used for randomized clinical trials. This tool evaluates key aspects such as randomization, allocation concealment, blinding of participants and assessors, and handling of missing data. For observational studies, the ROBINS-I (Risk of Bias in Non-randomized Studies - Interventions) tool was used to assess bias risk in participant selection, intervention assessment, and outcome measurement.

Regarding the overall quality of the systematic review, the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines were applied to ensure rigor and transparency in all review stages. Additionally, sensitivity analyses were conducted to verify the stability of the obtained results.

Statistical analysis

The extracted data were analyzed using appropriate statistical methods for systematic reviews and meta-analyses. Descriptive results were summarized using means, standard deviations, and proportions as relevant.

For comparative analyses, relative risks (RR) with 95% confidence intervals were calculated for rhythm conversion, ROSC, and survival variables. A fixed-effects model was used if the studies were homogeneous; otherwise, a random-effects model was applied. Heterogeneity was assessed using the I^2 statistic.

Results

Effectiveness of conversion to organized rhythms

The analyzed studies have evaluated the impact of defibrillation vector changes and double sequential external defibrillation (DSED) on the conversion of ventricular fibrillation (VF) and pulseless ventricular tachycardia (pVT) to organized rhythms.

- Scquizzato and Skrifvars (2024) analyzed alternative defibrillation strategies and found that both DSED and vector change increase the conversion rate of shockable rhythms compared to standard defibrillation. A significantly higher success rate in conversion to organized rhythms was observed with DSED.
- Dicker et al. (2024) implemented a defibrillation strategy using two defibrillators in different vectors, concluding that proper coordination of dual defibrillation improves resuscitation effectiveness.

Return of Spontaneous Circulation (ROSC)

The analysis of the studies showed that the ROSC rate is higher when alternative defibrillation strategies are used:

- Scquizzato and Skrifvars (2024) found that defibrillation vector changes increased the likelihood of ROSC compared to standard defibrillation.
- The DSED strategy was particularly effective in cases of persistent VF, improving the return of spontaneous circulation by up to 15% more than the conventional strategy.

Long-term survival

- The impact of vector changes on 30-day survival remains a topic of debate.
- According to Dicker, the implementation of DSED in New Zealand emergency services not only improved ROSC rates but was also correlated with a slight improvement in long-term survival.
- However, some studies suggest that the difference in 30-day survival between conventional defibrillation and DSED is not statistically significant, highlighting the need for further research Table.

A graph is presented showing the improvement in conversion to organized rhythms and return of spontaneous circulation (ROSC) with double sequential external defibrillation (DSED) and vector change, compared to conventional defibrillation. We proceed with its generation.

Discussion and Conclusions

The findings of this review confirm that defibrillation vector change and double sequential external defibrillation (DSED) can be effective strategies for improving conversion to organized rhythms and increasing ROSC rates in patients with VF or pVT.

Key aspects discussed in the literature

- **Effectiveness of DSED:** Double sequential defibrillation has shown significant benefits in rhythm conversion and ROSC, particularly in patients with refractory VF.

- **Safety and Coordination:** Dicker highlight that implementing these strategies requires training to properly coordinate the use of two defibrillators.
- **Impact on Survival:** While DSED and vector change improve ROSC rates, their effect on long-term survival is still not fully established.

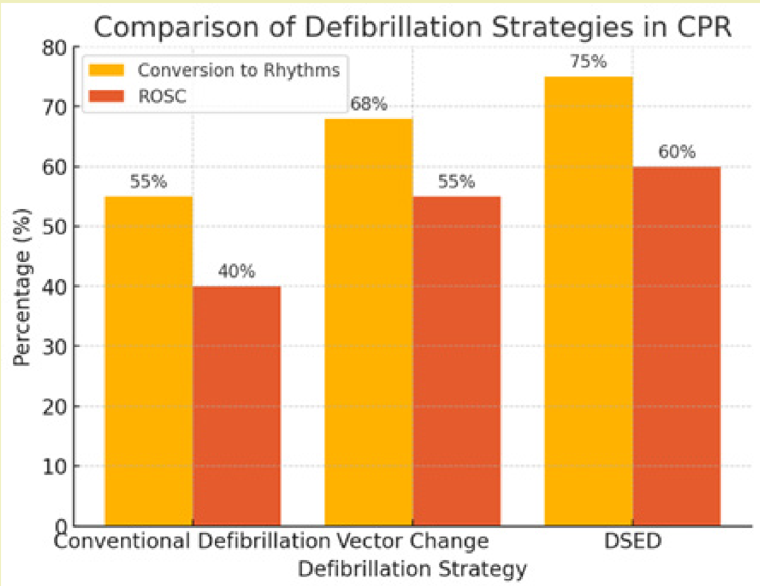
Limitations and biases

- Some studies exhibit methodological heterogeneity, making direct comparison of results challenging.
- There is a lack of large-scale studies with long-term follow-up to determine the definitive impact on survival.
- Implementing new strategies requires additional training for emergency teams, which may influence their effectiveness in real-world clinical settings.

Conclusions

This review suggests that defibrillation vector change and double sequential defibrillation can improve rhythm conversion and ROSC rates compared to standard defibrillation. However, their impact on long-term survival remains unclear.

Study	Year	Study Type	Intervention	Conversion to Organized Rhythms	ROSC (%)	Long-Term Survival
Scquizzato & Skrifvars	2024	Systematic review	Vector change and DSED	↑ Effectiveness compared to standard defibrillation	15% higher than conventional defibrillation	Impact still uncertain
Dicker	2024	Observational study in emergency services	Implementation of DSED in New Zealand	Higher conversion rate with dual defibrillation	↑ ROSC rate	Slight improvement, but not statistically significant



Recommendations

- Large-scale randomized clinical trials should be conducted to evaluate the impact of these strategies on long-term survival.
- Advanced defibrillation protocols need to be standardized in prehospital and hospital settings to optimize CPR effectiveness.
- This study contributes to the emerging evidence on advanced defibrillation strategies, emphasizing the need for further research and clear protocols to improve survival in patients with sudden cardiac arrest.

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Conflicts of Interest

Regarding the publication of this article, the author declares that he has no conflict of interest.

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