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Review article

Monophasic and biphasic shock for transthoracic conversion of atrial fibrillation: Systematic review and network meta-analysis☆

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ABSTRACT

Objectives: Conduct a systematic review of the literature to compare the efficacy of different biphasic and monophasic shock waveforms technologies for transthoracic cardioversion of Atrial Fibrillation (AF).
Methods: We searched PubMed, EMBASE, The Cochrane Library, LILACS and ClinicalTrials.gov databases for randomized clinical trials comparing two or more defibrillation waveforms when performing elective transthoracic cardioversion of AF. The outcomes assessed were 1st shock success, overall success, cumulative energy and number of shocks to restore Normal Sinus Rhythm.
Results: Were included 23 trials involving 3046 patients, 5 biphasic and the monophasic waveform. Direct meta-analysis revealed that Biphasic waveforms have higher chance to achieve cardioversion in the 1st shock (OR: 3.2; 95% CI 2.2–4.7) and after a sequence of attempts (OR:2.4; 95% CI 1.5–3.9), requiring 296 less Joules (95% CI 356–237) and 0.74 less shocks (95%CI 1.03–0.44) when compared to Monophasic. Network meta-analysis showed no significant differences between the Biphasic technologies of PhysioControl ADAPTIV, Philips SMART and ZOLL Rectilinear, in any of the four outcomes.
Conclusion: The evidences points to a Biphasic waveform superiority over Monophasic to perform AF cardioversion, supporting current guidelines to use less energy when using a Biphasic defibrillator. It is suggested that the Biphasic defibrillators from PhysioControl ADAPTIV, Philips SMART and ZOLL Rectilinear have similar efficacy and the use of any of them may result in similar chances, energy and number of shocks to achieve successful AF cardioversion.

Introduction

Electrical cardioversion for the treatment of Atrial fibrillation (AF) is classified as a Class I treatment when pursuing rhythm-control strategy (LOE B). Its benefits have been demonstrated when a rapid ventricular response to AF does not respond promptly to pharmacological strategies and contributes to other comorbidities (LOE C) and when it is associated with hemodynamic instability (LOE C).[1] It is also known that biphasic shock waveforms need lower energy than monophasic shock waveforms for transthoracic cardioversion of AF. Recommendations for initial energy have been set to 120 J for biphasic waveforms, and 200 J for monophasic waveforms.[2] Animal studies suggest that lower energy biphasic shocks decrease the risk of myocardial dysfunction.[3]

Overall, in guidelines and literature reviews, Biphasic waveform shocks are treated as equal, and possible differences between Biphasic waveform technologies have not yet been completely clarified. A recent systematic review of nine studies on the treatment of AF compared monophasic and biphasic technologies demonstrating better performance of the Biphasic, but no distinction of the biphasic technologies were evaluated or reported.[4]

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Two major types of biphasic waveforms are known as Rectilinear Biphasic Waveform (RBW) and Biphasic Truncated Exponential (BTE.) Different BTE manufactures can have different peak voltages, positive and negative cycle's durations and tilts. In both types of biphasic waveforms the defibrillator reads the patient's transthoracic impedance during energy delivery, and adjusts its outputs in order to deliver the selected energy to the patient. However they differ in how they adjust their output to compensate for the patient's impedance. Rectilinear Biphasic Waveform (RBW), developed by Zoll™, has a 200 J limit and adjusts its internal impedance to deliver a constant current. One major Biphasic Transthoracic Exponential waveform is the ADAPTIV™ developed by PhysioControl™. It has a 360 J limit and controls lead-edge voltages and adjusts pulse duration. Another major BTE waveform is the Philips SMART™ Biphasic, it has a 200 J limit, constant edge voltages and it controls pulse tilts and adjusts pulse duration.[5–7] A number of randomized control trials have evaluated the safety and performance of these technologies and others, yet further investigation is needed to better understand these differences. Thus, the aim of this study was to conduct a systematic review and network meta-analysis of randomized control trials to compare the efficacy of different biphasic waveforms and monophasic shock waveforms, applied through the thorax, for the conversion of Atrial fibrillation. The outcomes compared were Cumulative Energy, Number of Shocks, First Shock Success Rate and Overall Success Rate to restore normal sinus rhythm (NSR) in patients with AF undergoing elective cardioversion therapy.

Methods

Protocol and registration

This systematic review is reported in accordance with the Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) statement [8] and is registered in the Prospero database [CRD42014010479].

Eligibility criteria

Participants: Patients diagnosed with AF, persistent or not, undergoing elective cardioversion.

Interventions: Studies where the cardioversion shock therapy delivered through the thorax in attempt to restore NSR was evaluated reporting the number of shocks delivered, the mean energy delivered and success rate to restore NSR.

Comparison: Group receiving any Biphasic shock technology compared to a group receiving Monophasic shock or group receiving one type of Biphasic technology compared to a group receiving other type of Biphasic technology.

Outcomes: The outcomes were Cumulative Energy representing the mean cumulative energy necessary to restore NSR, the number of shocks, representing the mean number of shock necessary to restore NSR, first shock success rate, representing the odds ratio to restore NSR in the first shock attempt and overall success rate to restore NSR representing the odds ratio to restore NSR after all shocks attempt.

Types of Study: Studies designed as a Randomized Clinical Trial (RCT). No language limits were used. Studies with duplicated population and those that did not provide the type of biphasic technology used were excluded.

Information sources

A searched was performed using the following electronic databases: PubMed, EMBASE, Cochrane Central Registry of Controlled Trials, ClinicalTrials.gov, and Lilacs. The search included references of manually included articles and citation analysis of the included studies was performed using Google Scholar.

Search

The initial search comprised the Mesh terms *Atrial fibrillation, electric countershock, clinical trial* and their related entry terms. The search date was limited between 1/01/2000 and 6/31/2014. The complete search strategy used for the PubMed database is shown in Appendix Table 1. The searches were updated on 9/5/2014 to verify if newer publications were available.

Study selection

Titles and abstracts of the retrieved articles were independently evaluated by 2 reviewers (JFI and MG). Abstracts that did not provide enough information regarding the eligibility criteria were kept for full-text evaluation. Reviewers independently evaluated full-text articles and determined study eligibility. Disagreements were solved by consensus and when a consensus could not be reached a third reviewer (AM) was used.

Risk of bias

Risk of bias was evaluated according to the PRISMA statement recommendation. Study quality assessment included: selection of bias items, such as adequate sequence generation, and allocation concealment; performance of bias items, such as blinding of participants and personnel, and blinding of outcome assessment; attrition of bias evaluated through the assessment of incomplete outcome data; reporting of bias by the assessment of selective reporting; and other sources of bias. Two reviewers (JFI and MG) independently performed quality assessment, and disagreements were solved by consensus or by a third reviewer (AM).

Data extraction

Two reviewers (JFI and MG) independently conducted the data extraction and disagreements were solved by the third reviewer (AM). Characteristics such as cumulative energy, number of shocks, and first shock success to restore normal sinus rhythm were retrieved from the included studies. In studies where crossover analysis was conducted, the data was collected before the crossover was performed. Cumulative success rate and study upscaling energy protocol were used to calculate the cumulative energy and the number of shocks in studies that did not report these outcomes directly.

Data analysis

Considering that the studies have similar designs, same outcome measures and different upscaling energy protocols, we conducted direct meta-analysis pooling the results using a random effect, with mean differences for continuous outcomes such as cumulative energy and number of shocks and odd ratios outcomes such as 1st shock success and overall success, and calculated 95% confidence intervals and two sided P values. The Cochran Q test was used to assess heterogeneity and a value of P less than 0.1 was considered statistically significant. The I^2 testing was also used to measure the magnitude of the heterogeneity. The possibility of bias across studies was also evaluated using funnel plot of each of the trials effect size against the standard error (SE).

A network meta-analysis was also used, allowing for indirect comparison of two trials that have at least one treatment in common. The Bayesan Markov-chain Monte Carlo method using the statistical software Rstudio and JAGS package was used. The results