Initial Energy for External Electrical Cardioversion of Atrial Fibrillation

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Objective - *To investigate the initial energy level required for electrical cardioversion of atrial fibrillation (AF).*

Methods - *We studied patients undergoing electrical cardioversion in the 1st Multicenter Trial of SOCESP. Patients were divided into 2 groups according to the initial energy level of electrical cardioversion: 100J and ≥150J. We compared the efficacy of the initial and final shock of the procedure, the number of shocks administered, and the cumulative energy levels.*

Results - *Eight-six patients underwent electrical cardioversion. In 53 patients (62%), cardioversion was started with 100J, and in 33 patients (38%), cardioversion was started with ≥150J. Groups did not differ regarding clinical features and therapeutical interventions. A tendency existed towards greater efficacy of the initial shock in patients who received ≥150J (61% vs. 42% in the 100J group, p=0.08). The number of shocks was smaller in the ≥150J group (1.5±0.7 vs. 2.1±1.3, p=0.04). No difference existed regarding the final efficacy of electrical cardioversion and total cumulative energy levels in both groups. In the subgroup of patients with recent-onset AF (≤48h), the cumulative energy level was lower in the 100J group (240±227J vs. 324±225J, p=0.03).*

Conclusion - *Patients who were given initial energy of ≥150J received fewer counter shocks with a tendency toward greater success than those patients who were given 100J; however, in patients with recent-onset AF, the average cumulative energy level was lower in the 100J group. These data suggest that electrical cardioversion should be initiated with energy levels ≥150J in patients with chronic AF.*

Key words: atrial fibrillation, arrhythmia, electrical cardioversion

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Direct-current electrical cardioversion is one of the most widely used methods for restoration of sinus rhythm in patients with atrial fibrillation. Since its introduction by Lown et al [1] in 1962, it has been considered safe and effective, with expected success rates around 50% with a 100J initial shock and around 50% and 80% with a 200J initial shock [2]. Complications, such as postcardioversion arrhythmia, that vary from extrasystoles and bradycardias to ventricular fibrillation [3-5], myocardial injury [6], coronary spasms [7], as well as the complications related to sedation [8] may seldom occur. Despite the widespread use in clinical practice, no consensus exists on what should be the initial energy level for elective electrical cardioversion of persistent atrial fibrillation.

Methods

The 1st Multicenter Study of the Sociedade de Cardiologia do Estado de São Paulo (SOCESP) (The Cardiology Society of State of São Paulo) on the treatment of atrial fibrillation was composed by 2 phases. In the 1st phase, the cost/effective ratio of electrical cardioversion versus pharmacological cardioversion [8,9] was compared, and, in the 2nd phase, we compared the efficacy and safety of sotalol versus quinidine for the maintenance of sinus rhythm after atrial fibrillation [10,11] reversion. The ethical committees of all services involved approved the study protocol, according to the recommendations of the World Health Organization and the Helsinki declaration of 1975 for biomedical research involving human beings. After informed consent was obtained, patients were randomly assigned to undergo pharmacological or electrical cardioversion, using drugs and energy levels according to the experience of each center. The anesthetic used for electrical cardioversion, as well as the number of shocks and the energy administered, were left to the discretion of each investigator. Likewise, the type and dosage of antiarrhythmic drugs used for pharmacological cardioversion was also up to the investigator. In case of failure during pharmacological cardioversion, the investigator could attempt electrical cardioversion. The decision regar-

ding anticoagulation before cardioversion was also left up to the investigators, but it was strongly recommended that anticoagulation be used in patients with a high risk for thromboembolic events.

The study included clinically stable patients with atrial fibrillation of up to 6-months of duration. Exclusion criteria included hypokalemia (potassium serum ≤3.8mEq/L), any anesthetic contraindication, digitalis toxicity, congestive heart failure (New York Heart Association class III or IV), ventricular frequency lower than 50bpm, diastolic blood pressure >110 mmHg, alcohol and drug abuse, pregnancy or nursing, renal failure, myocardial infarction in less than 30 days, left ventricular ejection fraction lower than 40%, and the presence of diseases that could put the patient at risk. We avoided including patients with left atrium diameter greater than 5.2 cm on the echocardiogram with the purpose of selecting candidates eligible both for electrical and pharmacological cardioversion.

In the present study, we assessed only the group of 86 patients undergoing electrical cardioversion. Variables assessed were the efficacy of initial and final shock of electrical cardioversion, the number of shocks administered, and the total cumulative energy level. Patients were divided into 2 groups according to the initial energy level of cardioversion: 100J and ≥150J. If atrial fibrillation had been present for less than 48 hours, we defined it as recent-onset, and we defined arrhythmia that lasted more than 48 hours as chronic atrial fibrillation.

Variables studied are expressed as mean ± standard deviation and median, besides maximum and minimum values. We compared dichotomous variables using the chi-square test or, when Cochran restrictions were present, we used the Fisher exact test. Continuous variables were compared using the Mann-Whitney test. All tests were 2-tailed, and a p value <0.05 was considered significant.

Results

Restoration of sinus rhythm was obtained in 65 of the 86 patients who underwent external electrical cardioversion, with a success rate of 76%. The most frequently used drug for sedation of cardioversion was thiopentone sodium in 43% of the cases, which was administered alone or in association with midazolam (tab. I). Severe complications were not observed in either of the groups studied

Fifty-three patients (62%) received an initial shock of 100J, and 33 patients (38%) received an initial shock of ≥150J (16 patients received shocks of 150J, and 17 patients received shocks of 200J). Clinical and laboratory features of the patients are presented in table II. No significant difference was observed in the groups regarding clinical characteristics or left atrium diameter.

Anticoagulation was not used in 44 patients with recent-onset atrial fibrillation. Among 42 patients with chronic atrial fibrillation, 29 patients in whom arrhythmia had been present for more than 7 days and 4 of 12 patients (30%) who experienced atrial fibrillation from 48 hours to 7 days received anticoagulation medication. No cases of thromboembolism occurred.

Table I – Scheme of drugs used for sedation for electrical cardioversion

Drug	Total
thiopental sodium	35 (41%)
thiopental sodium + midazolam	2 (2%)
etomidate + fentanyl citrate	20 (23%)
etomidate	12 (14%)
etomidate + midazolam	1 (1%)
midazolam	10 (12%)
propofol	5 (6%)
propofol + fentanyl citrate	1 (1%)
Total	86 (100%)

Table II – Clinical characteristics of patients studied according to initial shock energy level

Variable	Group 100 J (n = 53)	Group ≥150 J (n = 33)	p
Age (years)	56 ± 12	57 ± 14	0.92
Men	28 (53%)	19 (58%)	0.67
Duration of AF >48h	30 (57%)	12 (36%)	0.07
Left atrium (cm)	4,3 ± 0,7	4,2 ± 0,8	0.85
Lone AF	22 (42%)	8 (24%)	0.10
Blood hypertension	21 (40%)	14 (42%)	0.80
NYHA Functional Class II	10 (19%)	2 (6%)	0.12
Previous use of antiarrhythmic drugs	12 (23%)	7 (21%)	0.88
Quinidine	4 (8%)	0	0.11
Quinidine + digitalis	3 (6%)	2 (6%)	0.65
Procainamide	2 (4%)	4 (12%)	0.35
Amiodarone	3 (6%)	1 (3%)	0.64

AF - atrial fibrillation; NYHA- *New York Heart Association*.

The immediate success rate for cardioversion was 42% (22 of 53 patients) in the group who received an initial energy shock of 100J and 61% in the group that received initial energy of ³150J (20 of 33 patients) (tab. IV). Patients who received higher levels of initial energy experienced greater restoration of sinus rhythm in the first shock (p=0.08). Of the 33 patients from the ≥150J group, the initial shock was effective in 10 of the 16 patients (62%) treated with 150J and 10 of the 17 patients that received 200J (59%) (p=0.83).

The total success rate after the last attempt at cardioversion was 75% (40 of 53 patients) in the 100J group and 76% in the ≥150J group (25 of 33 patients) (p=0.98). Cumulative success rates for each energy level are presented in figure 1. More substantial increases in success rate of 0.25%/J, occurred between 100J and 200J, and were only 0.06%/J for energy levels greater than 200J.

Electrical cardioversion was not successful in 24 patients, 7 patients (33%) received maximum energy of 200J, 4 patients (19%) received 250J, 6 patients (29%) received 300J, and 4 patients (19%) received 360J.

In 29 patients (34%), cardioversion was unsuccessful with energy levels ≤250J. Eleven of them (38%) did not receive energy ≥300J. In 18 patients (62%) in whom energy levels of 300 and 360J were used, cardioversion was achieved in 8 patients (44%).

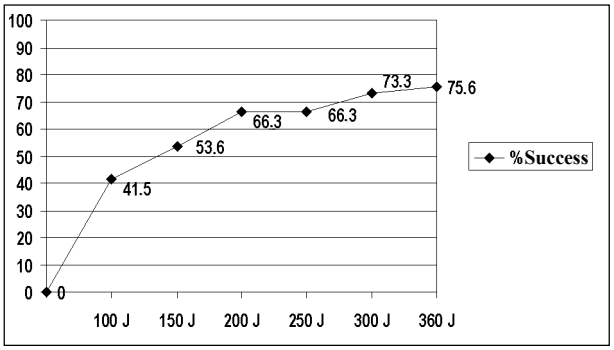

Fig. 1 - Cumulative success rates according to the energy level of shocks administered in electrical cardioversion.

The total number of shocks administered was significantly smaller in the ≥150J group compared with that in the 100J group (1.5±0.7 versus 2.1±1.3, respectively, p=0.04). Total cumulative energy did not differ between the groups (tab. III).

Regarding the presence of structural heart disease, the final efficacy of electrical cardioversion and initial shock, as well as the number of shocks administered, and the total cumulative energy levels did not differ between the 100J and the ≥150J groups, either in patients with "lone" atrial fibrillation or in patients with underlying heart disease (tab. IV).

In patients with recent-onset atrial fibrillation, total cumulative energy was smaller in the 100J group in comparison with that in the ≥150J group (240±227J versus 324±225J, respectively, p=0.03), with no differences regarding the efficacy of the final and initial shock and the number of shocks administered. In patients with chronic atrial fibrillation, the number of shocks was smaller in the ≥150J group compared with that in the 100J group (1.5±0.7 versus 2.4±1.4, respectively, p=0.04), with no differences regarding the efficacy of the initial shock, total cumulative energy, and cardioversion for sinus rhythm (tab. IV).

Table III – Comparison of electrical cardioversion among patients according to initial shock energy level

Variable (n = 53)	Group 100 J (n = 33)	Group ≥150 J	p
Success with initial shock	22 (42%)	20 (61%)	0.08
Final success of ECV	40 (75%)	25 (76%)	0.98
Number of shocks			0.04*
Mean ± SD	2.1±1.3	1.5±0.7	
Median	2	1	
Variation	1-6	1-3	
Cumulative energy (J)			0.30
Mean ± SD	348±337	317±202	
Median	250	200	
Variation	100-1470	150-860	

*p<0.05; ECV- electrical cardioversion; SD- standard-deviation.

Discussion

The 76% final success rate of electrical cardioversion is less than that previously reported in the literature. However, results are difficult to compare when clinical characteristics vary in the several studies. In our study, the electrical cardioversion procedure was not standardized. It was up to each center, so it may reflect the preference of the main Cardiology centers in the State of São Paulo. The use of different energy schedules, as well as the use of different defibrillators and paddle electrodes in each study center, may have influenced the final results of the procedure.

Pretreatment with antiarrhythmic drugs in only 22% of the patients has directly influenced cardioversion rates. Randomized studies show that previous use of antiarrhythmic drugs enhances the efficacy of electrical cardioversion or, at least, decreases early recurrence of atrial fibrillation [12-15].

Electrical cardioversion had maximum energy levels

Table IV – Analysis of electrical cardioversion in the subgroups regarding the presence of structural heart disease and atrial fibrillation duration

Structural Heart Disease		Absent (n = 30)			Present (n = 56)	
Variable	100 J (n = 22)	≥150 J (n = 8)	p	100 J (n = 31)	≥150 J (n = 25)	p
Success of initial shock	9 (41%)	6 (75%)	0.34	13 (42%)	14 (56%)	0.30
Final success of ECV	17 (77%)	6 (75%)	0.62	23 (74%)	19 (76%)	0.88
Number of shocks	2.2±1.5	1.5±0.9	0.17	2.0±1.1	1.5±0.6	0.13
Cumulative energy (J)	400±413	300±236	0.94	312±272	323±195	0.23
Duration of atrial fibrillation		Recent-onset (≤48h) (n = 44)			Chronic (>48h) (n = 42)	
Variável	100 J (n = 23)	≥150 J (n = 21)	p	100 J (n = 30)	≥150 J (n = 12)	P
Success of initial shock	13 (57%)	13 (62%)	0.72	9 (30%)	7 (58%)	0.25
Final success of ECV	20 (87%)	16 (76%)	0.55	20 (67%)	9 (75%)	0.72
Number of shocks	1.7±0.9	1.5±0.7	0.73	2.4±1.4	1.5±0.7	0.04*
Cumulative energy (J)	240±227	324±225	0.03*	431±385	305±164	0.77

*p<0.05; ECV- electrical cardioversion.

limited to 200 to 250J in about 50% of the patients considered as unsuccessful, and to 300J in 29% of these cases. Only 19% of the procedures depleted the possibilities of the method, using 360J of energy. Several studies had thresholds higher than 200J in up to 74% of the cases [16-18], and probably the success rate would increase if 300 to 360J of energy were attempted in all cases considered unsuccessful. In our study, the use of ≥300J of energy in the cases where previous ≤250J shocks had failed increased the cardioversion rate in 44% of patients. Therefore, if all the cases had undergone a ≥300J shock, we should expect 5 more cases of restoration of the sinus rhythm, resulting in a total cardioversion rate of 81% (70 of 86 patients).

In our study, the most frequently used initial energy was 100J in 62% of the cardioversions performed. None of the cardioversions was initiated with energy levels > 200J. The ≥150J group tended to be more successful compared with the 100J group (61% versus 42%, p=0.08). In a nonrandomized study, Sermasi et al [19] compared groups that received 100 and 200J of initial energy and observed that higher initial energy resulted in greater efficacy of the initial shock (36% versus 13%). Ricard et al [20], in a nonrandomized prospective study in patients with atrial fibrillation lasting more than 24 hours, reported success rates of 22%, 48%, 75%, and 96% with 40 to 50J, 80 to 100J, 160 to 200J, and 360J, respectively. Joglar et al. [21], in the only randomized study for the assessment of initial energy of elective cardioversion of atrial fibrillation, also had higher efficacy of shocks using higher initial energy levels: cardioversion rates were 14% with 100J, 39% with 200J, and 90% with 360J.

In our study, no differences existed between the groups regarding the final success of the procedure (75% in the 100J group and 76% in the ≥150J group). Sermasi et al [19] did not find differences in final cardioversion rates (87% in the 100J group and 85% in the 200J group). Likewise, Joglar et al [20] reported similar final efficacy between the groups studied (90% in the 100 and 200J groups and 100% in the 360J group).

We observed that, when cardioversion was started with 100J energy, a significantly greater number of shocks were administered (2.1±1.3 versus 1.5±0.7 in the ≥ 150J group). Joglar et al [21] also noticed that the total number of shocks administered were was higher when initial energy levels were lower (2.8±1.2 with 100J; 2.2±1.4 with 200J, and 1.1±0.5 with 360J). The lower number of shocks administered in cardioversion is interesting especially because of a shorter sedation period, reducing risks like nausea, vomiting, and respiratory depression.

Significant differences were not found among the groups regarding total cumulative energy levels (348±337J in 100J group versus 317±202J in ≥150J group). Sermasi et al [19] observed that cumulative energy in the 100J group was higher than that in the 200J group (303 versus 440J). Joglar et al [21] observed cumulative energy levels of 615±385J in the 100J group, 620±694J in 200J group, and 414±176J in 360J group, with significant differences between 100 and 360J groups (p=0.04), and a tendency toward in differences between the 100 and 200J groups (p=0.07), and no differences between the 100 and 200J groups. Unlike high-energy shocks used during cardiopulmonary resuscitation, recent studies [21-24] report that myocardium damage during electrical cardioversion of atrial fibrillation is minimal or absent.

In our study, those patients with recent-onset atrial fibrillation (lasting ≤48h) that received 100J of energy had a cumulative energy significantly lower than that in those patients in the ≥150J group. In patients with chronic atrial fibrillation (lasting >48h), the number of shocks administered was lower in the ≥150J group, similar to that in the total group. Although these data are limited due to the restricted number of patients in each subgroup, they are in accordance with previous studies that showed the relation between the immediate success of electrical cardioversion and the duration of arrhythmia [20]. The authors of this study concluded that 100J of energy may be appropriate for patients with recent-onset atrial fibrillation (lasting <24h); however, it can be very low for electrical cardioversion of patients with longer episodes of arrhythmia.

The recommendation regarding initial energy for external electrical cardioversion has gradually increased through the years. Recent recommendations for management of atrial fibrillation, such as the European and the Canadian consensus, have recommended an initial energy of 200J [25,26], despite the lack of evidence for this conduct. Additionally, some experts frequently use higher initial energy for cardioversion of atrial fibrillation [27]. However, guidelines still in use, such as those of the *Advanced Cardiac Life Support* of the *American Heart Association,* still recommend initial energy jolts of 100J [28].

The greatest limitation of our study is that randomization was not done with the purpose of assessing initial energy for electrical cardioversion. However, no significant difference existed regarding clinical and laboratory characteristics and previous treatment with antiarrhythmic drugs between the groups. Only an insignificant tendency existed in the ≥150J group to experience a small number of chronic atrial fibrillation episodes. This fact could explain the differences found, with a reduction in the number of shocks and a tendency toward greater efficacy of the initial shock in the ≥150J group. However, our data are in accordance with the studies that compared initial energy levels for elective electrical cardioversion of atrial fibrillation [19-21].

No thromboembolic complications occurred. Only 30% of the patients with atrial fibrillation lasting 48 hours to 7 days received anticoagulation medication in our study. Despite the lack of evidence regarding the exact duration of atrial fibrillation that determines anticoagulation before electrical cardioversion [25], current consensus recommend that all cases with arrhythmia lasting longer than 48 hours must receive anticoagulation medication [25,26,29,30].

Finally, our study showed that, for external electrical cardioversion of atrial fibrillation, a ≥150J initial energy level is related to a smaller number of shocks and a tendency towards greater success in the first shock. The success rate with a standard 100J initial energy level was very low.

However, in the subgroup of patients with recent-onset atrial fibrillation, cumulative energy was lower in the 100J group. We believe that, except for the patients with recent-onset arrhythmia, higher energies should be considered in the first shock of external electrical cardioversion of atrial fibrillation.

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