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Efficacy of low energy rectilinear biphasic cardioversion for regular atrial tachyarrhythmias

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Abstract

Background: *External, rectilinear biphasic cardioversion (RBC), as against monophasic cardioversion, requires lower energy and has been documented to be more effective in restoring sinus rhythm in atrial fibrillation (AF). There is, however, limited data on the optimal protocol of low energy RBC in atrial flutter (AFl) and regular atrial tachyarrhythmias (AT).*

Methods and results: *A prospective, single-center study was conducted, wherein 50 consecutive patients (mean age: 70.8 ± 8.7; 24 males) undergoing cardioversion of persistent or paroxysmal AFl or AT were randomized into two protocols of subsequent RBC shocks: 1) 10 J, 20 J, 50 J, 100 J, 200 J or 2) 20 J, 50 J, 100 J, 200 J. Initial energy was effective in 9/28 (32%) patients using Protocol 1 and in 12/22 (52%) patients using Protocol 2 (NS). In 9/12 patients with pacemakers, energy of 10 J or 20 J restored sinus or atrial-paced rhythm. Mean cumulative energy and number of shocks was 67 ± 70 J* vs *64 ± 62 J (NS) and 2.0 ± 0.8* vs *1.6 ± 0.7 ($p = 0.05$) for both protocols, respectively. Mean successful energy was higher for AFl patients than for AT patients 66 ± 49 J* vs *30 ± 19 J, $p < 0.04$. In approximately 25% of patients, conversion of AFl/AT into AF was observed after initial energy.*

Conclusions: *Low energy RBC is effective in 32–52% of patients with AFl/AT. Energy of 50 J is effective in 73% of patients and should be recommended as an initial energy in regular AT. Low energy RBC may be especially indicated in patients with pacemakers.* (Cardiol J 2011; 18, 1: 33–38)

Key words: atrial flutter, atrial tachycardia, biphasic electrical cardioversion

Introduction

Regular atrial tachyarrhythmias — atrial flutter (AFl) and atrial tachycardia (AT) — are common disorders that occur in the general population with a frequency of approximately 0.00088% [1]. Despite different etiologies, clinical management of both arrhythmias includes antiarrhythmic drugs, cardioversion or ablation treatment [2–4].

Current ACC/AHA/ESC guidelines recommend the use of an external monophasic waveform cardioversion for termination of atrial arrhythmias with an initial energy of 50 J and 200 J for AFl and atrial fibrillation (AF), respectively [4, 5]. There is no recommendation for cardioversion of atrial tachycardia. Compared to monophasic cardioversion, external, rectilinear biphasic cardioversion (RBC) requires less energy and has been documented to be more effective in terminating AF [6–8]. The use of low energy RBC seems to be especially important in patients with AFl or AT and with an implanted pacemaker due to possible post-shock sensing or pacing dysfunction.

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There is, however, limited information on the prospective evaluation of the initial energy settings of rectilinear RBC required to terminate regular atrial tachyarrhythmias. Therefore, the aim of this study was to assess the efficacy and outcome of low energy RBC protocols in patients with AFl or AT.

Methods

Data collection

A prospective, single-center, randomized study was conducted. Consecutive patients with AFl or AT hospitalized between 1 October, 2002 and 25 February, 2007 and classified for DC cardioversion entered the study. AFl was defined as presence of F waves, negative in leads II and III, positive in lead aVR for typical AFl and reversed for atypical AFl (duration 200–350/min). AT was diagnosed when atrial rhythm with isoelectric line between every P wave was present. All patients included in the study signed an informed consent before the cardioversion procedure.

The research was conducted according to the guidelines set out in the Declaration of Helsinki and has been approved by our Institutional Committee on Human Research.

The exclusion criteria were standard contraindications to cardioversion, such as: duration of arrhythmia lasting longer than 48 hours with no documented anticoagulation therapy four weeks prior to the procedure or clots in the atria found on transesophageal echocardiography (TEE). Selected patients were randomized to two protocols (Protocol 1 or 2) of subsequent rectilinear RBC (ZOLL M-Series defibrillator, USA) shocks: 1) 10 J, 20 J, 50 J, 100 J, 200 J; or 2) 20 J, 50 J, 100 J, 200 J. External, hand-held paddle electrodes were used in the sternum-apex position. Patients were sedated routinely with etomidate. A shock was defined as successful if sinus or atrial-paced rhythm was restored for more than one minute. In cases of induction of AF after initial RBC shock, patients were treated with 50 J shock and higher energy setting. The efficacy of the procedure was assessed during the 24 hours following cardioversion.

Prior to the cardioversion, all patients were treated with appropriate anticoagulation therapy, recommended by current guidelines [9]. Patients with persistent regular atrial tachyarrhythmia (> 48 h) were treated for four weeks with effective dosage of vitamin K antagonists (INR range 2.0–3.0). In patients with indication for antiarrhythmic therapy before four weeks of effective anticoagulation, the TEE was performed before cardioversion. In patients with paroxysmal arrhythmia (<48 h) low molecular weight heparin was used.

Statistical analysis

Continuous variables are presented as mean ± standard deviation (SD) and median values, categorical variables were described as frequencies and percentages. Continuous variables were compared by the unpaired Student *t* test, and categorical variables were compared by the χ^2 test. Statistical significance was considered when p value < 0.05.

Results

Fifty patients (mean age: 70.8 ± 8.7; 24 males) were included in the study. Patients' clinical characteristics are summarized in Tables 1 and 2. No significant differences were found between patients assigned to both protocols. Duration of AFl or AT varied between one and 360 days (median 12 days) and had no influence on the result of the procedure. In three patients, the duration of arrhythmia was unknown.

In the studied group, 91 RBC shocks were delivered. Initial energy was efficient in 9/28 (32%) patients in Protocol 1 (10 J) and in 12/22 (52%) patients in Protocol 2 (20 J); p = NS. The cumulative success rate for the second stage of Protocol 1 (20 J) was 65%. The restoration of sinus or atrial-paced rhythm after a 50 J shock was similar in both protocols (75% *vs* 73%, p = NS). The cumulative success rates for both protocols are shown in Figure 1.

Mean cumulative energy for restoration of sinus or atrial-paced rhythm was 67 ± 70 J (median 60 J) for Protocol 1 and 64 ± 62 J (median 25 J) for Protocol 2 (p = NS), whereas mean successful energy was 51 ± 47 J (median 50 J) and 49 ± 39 J (median 25 J), respectively (p = NS). The mean number of shocks needed for restoration of sinus or atrial paced rhythm was significantly lower for Protocol 2 than for Protocol 1 (1.6 ± 0.7 *vs* 2.0 ± 0.8; p = 0.05).

Mean cumulative energy, as well as mean successful energy required for restoration of sinus or atrial-paced rhythm, were significantly higher for AFl patients than for AT patients in both protocols: 93 ± 81 J (median 70 J) *vs* 38 ± 27 J (median 20 J), $p < 0.04$ and 66 ± 49 J (median 50 J) *vs* 30 ± 19 J (median 20 J), $p < 0.04$. Compared to patients with AT, patients with AFl tended to require a higher mean number of shocks for restoration of sinus or atrial-paced rhythm (1.7 ± 0.8 *vs* 2.0 ± 0.9; p = NS). The initial energy (10 J or 20 J depending on protocols) was effective in 41% of individuals with AFl and in 41% of AT patients (p = NS).

Table 1. Clinical characteristics of patients randomized to Protocol 1 and Protocol 2.

	Protocol 1 (n = 28)	Protocol 2 (n= 22)	P
Age (years)	72 ± 6	68 ± 5	NS
Male	13	11	NS
AFl/AT	10/18	12/10	
Mean AFl/AT duration	111 ± 229	131 ± 234	NS
Weight [kg]	76 ± 8	86 ± 7	NS
Previous TIA	3	1	NS
IHD	12	8	NS
Previous MI	5	6	NS
Previous PTCA	1	1	NS
Previous CABG	1	1	NS
Dyslipidemia	6	8	NS
Active smoking	3	2	NS
Hypertension	21	15	NS
Diabetes	7	7	NS
Previous cardioversion	9	5	NS
History of AF	12	10	NS
History of AFl or AT	8	10	NS
Beta-blocker	19	10	NS
Amiodarone	4	5	NS
Sotalol	4	3	NS
Propafenone	3	3	NS

Continuous variables are expressed as mean ± standard deviation; other values are number of patients; AF — atrial fibrillation; AFl — atrial flutter; AT — atrial tachyarrhythmia; TIA — transient ischemic attack; IHD — ischemic heart disease; MI — myocardial infarction; PTCA — percutaneous transluminal coronary angioplasty; CABG — coronary artery bypass grafting

Table 2. Clinical characteristics of patients with atrial flutter and atrial tachyarrhytmia.

	AFl (n = 22)	AT (n= 28)	P
Age (years)	66 ± 9	75 ± 7	< 0.001
Male	13	11	NS
Mean AFl/AT duration	60 ± 85	187 ± 314	NS
Weight [kg]	96 ± 26	74 ± 15	0.02
Previous TIA	0	4	NS
IHD	10	12	NS
Previous MI	6	6	NS
Previous PTCA	0	2	NS
Previous CABG	1	2	NS
Dyslipidemia	8	7	NS
Active smoking	2	3	NS
Hypertension	18	20	NS
Diabetes	7	8	NS
Previous cardioversion	6	12	NS
History of AF	9	14	NS
History of AFl or AT	9	8	NS
Beta-blocker	13	17	NS
Amiodarone	4	7	NS
Sotalol	2	5	NS
Propafenone	3	3	NS

Continuous variables are expressed as mean ± standard deviation; other values are number of patients. AF — atrial fibrillation; AFl — atrial flutter; AT — atrial tachyarrhythmia; TIA — transient ischemic attack; IHD — ischemic heart disease; MI — myocardial infarction; PTCA — percutaneous transluminal coronary angioplasty; CABG — coronary artery bypass grafting

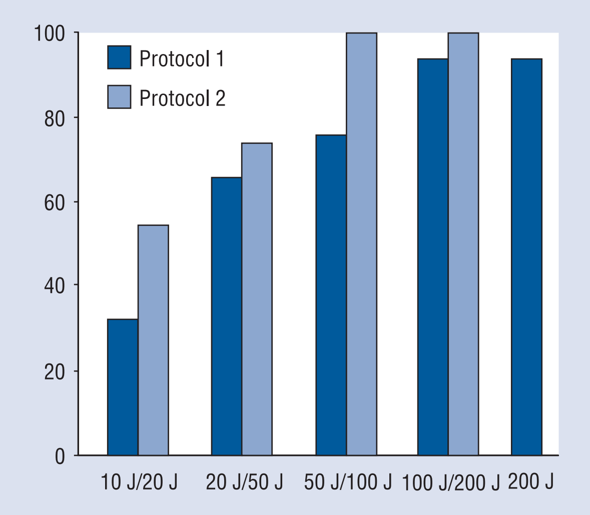

Figure 1. The cumulative success rates for every step of Protocols 1 and 2.

There were 12 patients with permanent atrial pacing included in the study (DDD pacing: nine patients; AAI pacing: three patients). Ten individuals from that group presented with AT and two with AFl. In nine of the 12 patients with a pacemaker, energy of 10 J or 20 J restored a sinus or atrial paced rhythm. Energy of 10 J was successful in one patient with AFl and in three patients with AT, whereas 20 J was effective in one patient with AFl and four patients with AT. In 50% of patients, initial energy was successful. Mean cumulative energy was 24 ± 15 J (median 30 J) in that group of patients.

In seven (25%) patients included in Protocol 1 and in four (22%) patients treated according to Protocol 2, conversions into AF within the first minute after the initial energy shock were observed. One patient in Protocol 1 converted into AF after the second stage of the protocol (20 J). There were no patients with a pacemaker in that group. There were no significant differences between these patients and individuals who did or did not develop AF during the procedure. Conversion into AF after initial energy was observed in 17% of patients with AFl and in 40% of patients with AT (p = NS). Mean cumulative and mean successful energy for restoration of sinus rhythm in patients with conversion of AFL/ /AT into AF were significantly higher than in patients without AF induction: 139 ± 83 J (median 120 J) *vs* 42 ± 36 (median 25 J); $p < 0.001$ and 102 ± 43 J (median 100 J) *vs* 33 ± 25 J (median 20 J), $p < 0.001$. Conversion of AT into AFl was observed in one patient after initial energy of 10 J.

Forty one out of 91 (45%) RBC shocks were unsuccessful. In eight of these 41 (19%) shocks, failure of cardioversion was due to early recurrence of arrhythmia after few sinus or atrial paced beats, whereas in the remaining 33 (81%) cases, cardioversion was unsuccessful even for a few seconds. In the early recurrence group, the same arrhythmia appeared again after 3/8 (36%) unsuccessful shocks; in the other five cases (64%), AF was induced after shocks.

There were no significant differences in the pharmacological treatment of both groups. In the AFl group, three patients was treated with amiodarone prior to cardioversion, and after the first stage of the protocol two of them converted into AF. In another three patients in that group, propafenone was used before DC shocks and there was no conversion into AF in that group. The restoration of sinus or paced atrial rhythm was achieved in all but one patient (98%). No serious complication (occurrence of post-cardioversion bradyarrhythmia, thromboembolic events, skin burns or pacing and sensing disorders in patients with implanted pacemaker) were noted. No early or late recurrent atrial arrhythmias were observed during 24-hours of observation.

Discussion

Our study revealed that a protocol of RBC for cardioversion of AFl/AT with initial energy of 20 J is slightly, but not significantly, more effective than a protocol starting with 10 J. Furthermore, the significantly lower number of shocks decrease the total time needed for procedure and duration of anaesthesia. These observations, with the similar rate of conversion into AF, favour the use of 20 J as the initial energy level.

This result agrees with recent studies that showed that for monophasic cardioversion of AFl, starting protocol from higher initial energy (50 J to 80 J) is effective and provides lower cumulative energy [5]. Other studies have suggested there is no statistical difference in success rates between 50 J monophasic and 20 J RBC (69% *vs* 66%, p = NS); moreover the RBC energy of 30 J was significantly more effective than monophasic 100 J [8]. It was also shown that for AFl, mean overall successful energy of RBC and monophasic cardioversion is 61 ± ± 46 J and 231 ± 108 J, respectively [7]. Similarly, there is evidence that the success rate of RBC and monophasic 20 J shocks was 41% and 42% of patients (p = NS), respectively, whereas 50 J shocks were effective in 77% and 80% of the patients (p = NS) [10]. In the same study, median energy for successful cardioversion was 50 J in both types of electrical waveforms. Optimal initial RBC energy seems to be 20 J or 50 J and it needs further prospective evaluation and verification of incidence of conversion into AF after RBC.

Conversion of AFl or AT into AF after low energy shocks was observed in earlier studies on monophasic cardioversion and it appears to be a limitation of low energy RBC [7]. In our recent study with 302 consecutive patients with persistent AF, the mean cumulative and mean successful energy needed for restoring sinus rhythm of RBC were 165 ± 140 J and 98 ± 69 J, respectively [11]. Similar results in patients converted into AF were obtained in this study.

The prevalence of induction of AF after monophasic cardioversion, as well as after low energy RBC, in patients with regular atrial tachyarrythmias has not been investigated in other studies. It seems that inducted AF is more frequent in low energy cardioversion and should be treated with a dosage of energy appropriate for a patient cardioverted due to AF as a primary disease. The importance and frequency of conversion into AF in monophasic and RBC with different initial energies needs further comparative evaluation.

The high success rate of low energy settings in patients with a pacemaker may be a result of lower weight in that group of patients (68.63 ± 13.12 *vs* 88.00 ± 23.14, p = 0.01). There were no differences in age or arrhythmia duration in both groups. Another potential explanation for high efficacy of RBC in paced patients is the favorable influence of pacing, preventing early arrhythmia recurrences.

There have been no previous studies evaluating external monophasic or biphasic cardioversion in AT. The results for the AT group were not compared to any other studies, but it seems that for cardioversion of AT in comparison to AFl, significantly lower RBC energy is required.

Limitations of the study

The protocol of the study was focused on the procedure of cardioversion. The number of patients included in the study limited investigation on the influence of duration of symptoms and medications before and after RBC. Due to 24 hours follow up, the study shows the short-term effectiveness of the RBC. The proportion of patients with a pacemaker was low. Comparison of sternum-apex and antero-posterior configuration for cardioversion of AT and AFl needs further evaluation, however antero-posterior configuration may be less appropriate for patients with pacemakers because it will mean the device will be closer. Antero-posterior configuration needs additional patches. We use paddles as a standard in our institution.

Conclusions

Low energy RBC is effective in 32–52% of patients, and may be especially indicated in patients with pacemakers in whom limitation of DC current is desirable. Low energy RBC is associated with about 20% of conversion into AF. Patients with AT and AFL had similar outcome of low energy RBC; therefore for both arrhythmias, a similar initial energy and protocol setting can be used. Due to a 74% cumulative success rate of energy of 50 J, mean successful energy about 50 J in both protocols, and risk of conversion into AF associated with lower initial RBC energies, energy of 50 J is the minimal acceptable energy needed to restore sinus or atrial-paced rhythm in AFl/AT. Energy of 50 J should be recommended for the RBC of regular atrial tachyarrhythmias and needs to be compared as an initial energy with higher settings.

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