Annals of Medicine

ISSN: 0785-3890 (Print) 1365-2060 (Online) Journal homepage: http://www.tandfonline.com/loi/iann20

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To cite this article: Jussi Jaakkola, Juha E. K. Hartikainen, Tuomas Kiviniemi, Ilpo Nuotio, Wail Nammas, Toni Grönberg, Anna Karmi, Antti Ylitalo & K. E. Juhani Airaksinen (2015) Ventricular rate during acute atrial fibrillation and outcome of electrical cardioversion: The FinCV Study, Annals of Medicine, 47:4, 341-345, DOI: 10.3109/07853890.2015.1031821

To link to this article: http://dx.doi.org/10.3109/07853890.2015.1031821

ANN MED

Annals of Medicine, 2015; 47: 341–345

ISSN 0785-3890 print/ISSN 1365-2060 online
DOI: 10.3109/07853890.2015.1031821

informa
healthcare

ORIGINAL ARTICLE

Ventricular rate during acute atrial fibrillation and outcome of electrical cardioversion: The FinCV Study

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Introduction. **The impact of ventricular rate (VR) on the outcome of electrical cardioversion (ECV) of acute atrial fibrillation (AF) is currently unknown. We aimed to determine the effect of VR during acute AF on the success of ECV, recurrence of AF, and occurrence of post-cardioversion complications in 30 days of follow-up.**

Methods. **A total of 6,624 ECVs were performed in 2,821 consecutive patients with AF lasting < 48 hours. VR ≤ 60 bpm was defined low, and VR ≥ 160 bpm high.**

Results. **The median VR before ECV was 109 bpm. The success rate of ECV was 94.2%. Bradycardia occurred in 62 (0.9%) and thromboembolic complications in 39 (0.6%) ECVs. Low VR was observed before 75 (1.1%) ECVs, and male sex was its only independent predictor. High VR was observed in 165 (2.5%) ECVs. The independent predictors of high VR were younger age, < 12 h episode duration, no previous history of AF, and alcohol abuse. Low or high VR were not related to the success of ECV, incidence of thromboembolic or bradycardic complications, or recurrence of AF, although VR was significantly ($P < 0.001$) lower in the patients in whom AF recurred.**

Conclusion. **VR during acute AF does not affect the efficacy or safety of ECV.**

Key words: Atrial fibrillation, bradycardia, electric countershock, heart rate, stroke

Key messages

- Our large multicenter study shows that ventricular rate does not affect the success of electrical cardioversion, incidence of thromboembolic or bradycardic complications, or recurrence of atrial fibrillation at 30-day follow-up, although the median ventricular rate was significantly lower in the patients in whom atrial fibrillation recurred.
- Contrary to common beliefs, low ventricular rate does not impair the success of cardioversion or predispose to bradycardic complications.
- Male sex is the most important predictor of low ventricular rate, whereas short disease history and short duration of atrial fibrillation episode are the most important features associated with high ventricular rate.

Introduction

Atrial fibrillation (AF) is the most common long-standing arrhythmia, and its disease burden is progressively increasing globally (1,2). AF leads to irregular and inappropriate ventricular rates (VR) causing symptoms and predisposing to potentially life-threatening thromboembolic complications (3).

Electrical cardioversion (ECV) is effective in converting patients to sinus rhythm in the emergency department setting (4–6), but the recurrence of AF is common (7,8). Cardioversion also exposes patients to thromboembolic and arrhythmic complications (6,7).

Since there are no data on the impact of VR during acute AF on the outcome of ECV, we decided to evaluate the effect of VR at the time of admission on the success of ECV, recurrence of AF, and occurrence of post-cardioversion complications in patients with acute AF.

Material and methods

This study is a part of the multicenter FinCV study (ClinicalTrials.gov Identifier: NCT01380574) assessing thromboembolic and arrhythmic complications after cardioversion of acute (< 48 hours) AF (9–11). All patients with a primary diagnosis of AF were identified from the institutional discharge registries of two university hospitals from 2003 through 2010 and one

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(Received 15 December 2014; accepted 13 March 2015)

central hospital during 2010 in Finland (Turku University Hospital, Turku; Kuopio University Hospital, Kuopio; Satakunta Central Hospital, Pori). Admission records and databases were used to review all patients above 18 years of age with acute AF who underwent cardioversion in the emergency clinics during the study period. In addition, only patients living in the hospital catchment area were included in order to get adequate follow-up data after the cardioversion. Each of these three hospitals is the only referral hospital responsible for the acute care of patients presenting with cardiac or stroke events in their catchment areas.

A total of 7,660 consecutive cardioversions were performed in 3,143 patients with acute AF. Out of these cardioversions, 6,906 performed in 2,868 patients were electrical. The information on admission VR was missing in 282 cases, and thus the study consisted of 6,624 ECVs performed in 2,821 patients.

ECVs were performed according to the contemporary guidelines under general anesthesia. During and after the procedure, ECG, blood pressure, and oxygen saturation were monitored. Paddles or pads were positioned in antero-posterior or anterolateral configuration. The energy ranged from 70 to 150 J with biphasic defibrillator devices and from 70 to 360 J with monophasic devices. A 12-lead ECG was controlled before and after the procedure. ECVs were performed by biphasic defibrillator after 2004. Patients were followed from the patient records for 30 days after the cardioversion to evaluate the recurrence of AF.

All case records were reviewed with a standardized data collection protocol to acquire information on the baseline characteristics of the patients and the management during the index ECV as well as during the 30-day follow-up period. The diagnosis of AF was confirmed by 12-lead electrocardiogram according to the standard criteria. VR of AF was registered from the automatic computer analysis of the first electrocardiographic recording during the AF episode. VR $\leq$ 60 bpm was considered low and VR $\geq$ 160 bpm high. All possible arrhythmic and thromboembolic complications, death, and any conditions that caused the patient to consult a physician within 30 days after the ECV were recorded. The duration of the index arrhythmia was determined from the patient records.

The two primary pre-specified study end-points of this substudy were the success of the ECV procedure and recurrence of AF within 30 days after the index ECV. ECV was considered successful if sinus rhythm was restored and the patient was discharged from the emergency clinic in sinus rhythm. AF was considered recurrent when the patient presented with ECG-documented AF during the 30-day follow-up period. Secondary end-points included post-procedural bradycardia and thromboembolic complications, as well as mortality at 30-day follow-up. Bradycardia was defined as heart rate $<$ 40 bpm and asystole as $>$ 5 s with no cardiac electrical activity immediately after ECV. Stroke was defined as a permanent focal neurological deficit adjudicated by a neurologist, and confirmed by computed tomography or magnetic resonance imaging. Peripheral arterial embolism was defined as signs/symptoms of peripheral ischemia associated with a positive imaging test.

The study protocol was approved by the Medical Ethics Committee of the Hospital District of Southwest Finland and the ethics committee of the National Institute for Health and Welfare. Informed consent was not required because of the registry nature of the study. The study conforms to the Declaration of Helsinki.

Statistical analyses were performed with SPSS (version 22.0, SPSS, Inc., Chicago, IL, USA) and SAS (version 9.3 SAS Institute, Inc., Cary, NC, USA) software. Variables are presented as mean $\pm$ SD, median [interquartile range], or absolute number and percentage, as appropriate. The *t* test, Mann–Whitney *U* test, and Kruskal–Wallis test were used for analysis of continuous variables. Chi-square and Fisher exact tests were used to compare differences between proportions. Based on the results of bivariable comparisons, multivariable logistic regression analyses with repeated measures option were used in evaluations of high and low VR predictors. Two-sided differences were considered significant if the null hypothesis could be rejected at the 0.05 probability level.

Results

Baseline characteristics

Altogether 6,624 ECVs were performed in 2,821 patients; 6,239 (94.2%) of the ECVs were successful. The median age of the patients at the time of ECV was 63.4 [15.2], and in 4,294 (64.8%) cases they were men. The median VR before ECV was 109 [37] bpm. There was a significant VR difference between the genders ($P < 0.001$): 106.9 bpm (95% CI 106.2–107.7) and 115.6 bpm (95% CI 114.7–116.5) for men and women, respectively. The baseline characteristics of the patients at the time of ECV according to VR during AF are presented in Table I. The use of oral anticoagulants and rhythm and rate control medication at the time of ECV according to VR during AF are presented in Table II. The distribution of VR according to the duration of AF is shown in Figure 1.

VR and outcome of cardioversion

Bradycardia (VR $<$ 40 bpm or asystole $>$ 5s) occurred in 62 (0.9%) and thromboembolic complications in 39 (0.6%) ECVs. VR had no effect on the success rate of ECV and did not affect the incidence of bradycardia, asystole, stroke, or other emboli after the procedure, nor did it have an effect on mortality or rate of early recurrences (Table III). The results were comparable in cases where the patients ($n =$ 1,189) were not receiving any rate or rhythm control medication (Table IV). Although high or low VR did not significantly influence the rate of recurrence, VR was slightly but significantly lower ($P <$ 0.001) in the cases where AF recurred compared to those who remained in sinus rhythm (107.5 bpm, 95% CI 106.2–108.8 versus 110.5 bpm, 95% CI 109.8–111.2).

Predictors of low and high VR

Low VR ($<$ 60/min) was observed in 75 (1.1%) ECVs; in most cases the patients presenting with a low VR were men, and they more often experienced an AF episode within the preceding month, and the duration of the AF episode was longer (Table I). In multivariable logistic regression analyses, male sex (odds ratio [OR] 5.44; 95% CI 2.29–12.89; $P < 0.001$) was the only independent predictor of low VR.

High VR ($\geq$ 160/min) was observed in 165 (2.5%) ECVs. In cases presenting with a high VR, the patients were younger, more often women, diabetic, heavy alcohol consumers, and had a higher CHA_2DS_2-VASc score compared to patients with low VR. These AF episodes were more likely short ($<$ 12 h) and represented the first episode of the patient (Table I). In multivariable logistic regression analyses the independent predictors of a high VR were: first AF episode of the patient (OR 2.03; 95% CI 1.37–3.00; $P < 0.001$), short ($<$ 12 h) duration of the index episode (OR 1.62; 95% CI 1.15–2.28; $P = 0.006$), alcohol abuse (OR 3.69; 95% CI 1.91–7.13; $P < 0.001$), and young age (OR 1.58; 95% CI 1.04–2.42; $P = 0.03$).

Discussion

To the best of our knowledge, no previous study has focused on the effect of VR on the success and complications of ECV in

Table I. Baseline characteristics of the 2,821 patients at the time of ECV according to VR during AF.

	VR ≤ 60	60 < VR < 160	VR ≥ 160	*P* value
No. of ECVs	75	6384	165	
No. of patients	62	2755	121	
Age, years	62.0 [18.6]	63.6 [15.2]	59.8 [15.3]	0.001
Age groups				0.004
< 65	45 (60.0)	3504 (54.9)	113 (68.5)	
65–75	25 (33.3)	1996 (31.3)	35 (21.2)	
> 75	5 (6.7)	884 (13.8)	17 (10.3)	
Female gender	7 (9.3)	2259 (35.4)	64 (38.8)	< 0.001
No previous history of AF	13 (17.3)	1309 (20.5)	56 (33.9)	< 0.001
Prior AF < 30 days	17 (22.7)	1089 (17.1)	23 (13.9)	0.246
Duration of AF episode				0.002
< 12 hours	24 (32.0)	2904 (45.5)	94 (57.0)	
12–24 hours	30 (40.0)	2334 (36.6)	44 (26.7)	
24–48 hours	21 (28.0)	1146 (18.0)	27 (16.4)	
Hypertension	30 (40.0)	3157 (49.5)	62 (37.6)	0.003
Diabetes mellitus	5 (6.7)	627 (9.8)	19 (11.5)	0.503
Alcohol abuse	1 (1.3)	144 (2.3)	14 (8.5)	< 0.001
Coronary artery disease	8 (10.7)	1184 (18.6)	31 (18.8)	0.215
Vascular disease	10 (13.3)	1008 (15.8)	17 (10.3)	0.137
LVH	14 (19.2)	960 (15.4)	18 (11.3)	0.234
History of stroke or TIA	2 (2.7)	482 (7.6)	8 (4.8)	0.122
CHA_2DS_2-VASc score				0.002
0–1	46 (61.3)	2439 (42.8)	398 (47.1)	
2	17 (22.7)	1205 (21.1)	154 (18.2)	
3–5	11 (14.7)	1820 (31.9)	263 (31.1)	
> 5	1 (1.3)	236 (4.1)	30 (3.6)	
Implanted pacemaker	6 (8.0)	335 (5.3)	5 (3.0)	0.249

Values are presented as median [interquartile range] for age, and *n* (%) for rest of the variables.
AF = atrial fibrillation; ECV = electrical cardioversion; LVH = left ventricular hypertrophy; TIA = transient ischemic attack; VR = ventricular rate.

patients with AF. The current study documents that ECV is an effective and safe procedure in acute rhythm management of AF regardless of VR. High or low ventricular rate had no effect on the incidence of arrhythmic or thromboembolic complications after ECV. Male sex was the most important predictor of low VR, whereas first AF episode, short (< 12 h) duration of arrhythmic symptoms, and alcohol abuse were the most important features associated with high VR. Recurrence of AF within 30 days after ECV was relatively common (17.2%), but could not be predicted by VR prior to ECV.

Little is known about the significance of the VR of AF on the success or complications of ECV as there has been no previous research on this issue. Low VR is often considered to impair the success of cardioversion and predispose to bradycardic complications. One could speculate that slower atrioventricular conduction during AF might reflect disease in the atrioventricular node, which could involve also the rest of the conduction system and the sinus node, and ECV might reveal sick sinus syndrome. Our findings, however, clearly show that this is not the case in acute AF. Low VR did not influence the success of ECV or increase the risk of bradycardic complications after ECV. On the other hand, high VR is known to impair left atrial appendage flow (12,13) and may also reflect higher atrial rate during AF (14), predisposing to thrombus formation in the left atrial appendage. In the present setting, high VR was, however, not associated with higher risk of thromboembolic complications.

Table II. The use of rhythm and rate control medication and oral anticoagulants by the 2,821 patients at the time of ECV according to VR during AF.

	VR ≤ 60	60 < VR < 160	VR ≥ 160	*P* value
No. of ECVs	75	6384	165	
No. of patients	62	2755	121	
Beta-blocker	47 (62.7)	4939 (77.4)	106 (64.2)	< 0.001
Digoxin	5 (6.7)	438 (6.9)	21 (12.7)	0.014
Verapamil	1 (1.3)	108 (1.7)	4 (2.5)	0.737
Class I AAD	20 (26.7)	1070 (16.8)	23 (13.9)	0.045
Class III AAD	3 (4.0)	273 (4.3)	3 (1.8)	0.316
Warfarin treatment	27 (36.0)	1973 (30.9)	31 (18.8)	0.002

Values are presented as *n* (%).
All categories, except warfarin, combine medication taken at home and received after admittance.
AAD = antiarrhythmic drugs; AF = atrial fibrillation; ECV = electrical cardioversion; VR = ventricular rate.

Our finding of higher VR in women during acute AF is in agreement with the analysis from the AFFIRM study (15) and a previous report on 32 patients which showed that women have higher VR during short AF episodes observed in Holter recordings (16). The higher heart rate in women may be related to gender-related differences in autonomic responses to arrhythmia, although differences in atrioventricular nodal function may also contribute (17). The onset of an AF paroxysm increases sympathetic nervous activity (18), and thus it is reasonable that variables indicating recent onset (no previous AF history, short duration of AF episode) predicted higher heart rate during AF. Alcohol consumption has previously been associated with an increase in β-adrenoceptor density in patients prone to alcohol-induced AF (19), and ethanol withdrawal is a known cause of increased adrenergic activity (20); these factors may contribute to the higher VR in this patient group in the setting of acute AF.

It has been reported that fast heart rate during sinus rhythm after successful ECV predisposes to AF recurrences (1,21), but the relationship between recurrences and VR during AF has remained less clear. In the AFFIRM study (15), early recurrences were less frequent in patients with a high VR during AF, whereas in another small study no connection between VR and AF recurrences was found (22).

Some limitations need to be addressed. The retrospective nature of analyzing data does not allow characterizing the study

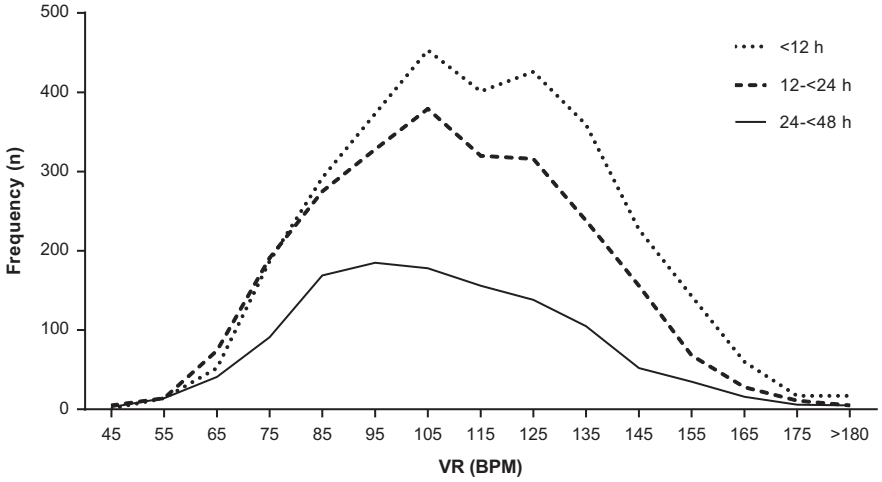

Figure 1. The distribution of ventricular rate (VR) at the time of electrical cardioversion (ECV) according to the duration of atrial fibrillation.

Table III. Success, complications, and early recurrences after ECV according to VR during AF.

	VR ≤ 60	60 < VR < 160	VR ≥ 160	*P* value
No. of ECVs	75	6384	165	
No. of patients	62	2755	121	
Success rate of ECV	72 (96.0)	6014 (94.2)	153 (92.7)	0.578
Recurrence of AF within 30 days[a]	12 (16.7)	1036 (17.2)	16 (10.5)	0.0889
Asystole (> 5 s)	0 (0.0)	49 (0.8)	1 (0.6)	1.000
Bradycardia (< 40 bpm)	0 (0.0)	21 (0.3)	0 (0.0)	1.000
Stroke	0 (0.0)	32 (0.5)	1 (0.6)	0.705
Other embolus	0 (0.0)	7 (0.1)	0 (0.0)	1.000
Death within 30 days	0 (0.0)	12 (0.2)	1 (0.6)	0.381

Values are presented as *n* (%).
[a] Only successful ECVs were included in the analysis: *n* = 6,239 (VR ≤ 60: *n* = 72; 60 < VR < 160: *n* = 6,014; VR ≥ 160: *n* = 153).
AF = atrial fibrillation; bpm = beats per minute; ECV = electrical cardioversion; VR = ventricular rate.

cohort as accurately as a prospective trial design, and so our findings are largely hypothesis-generating in nature. We were dependent on the interpretation of the arrhythmic symptoms by the physicians who performed the cardioversion and were responsible for the treatment decisions and the follow-up, but because of the good coverage of electronic patient records and the stability of the population, the outcome from all included patients at the subsequent outpatient and hospital visits could be reliably reviewed. However, the retrospective design of the study avoids any selection bias and reflects real-world practice. Ideally we should have had also reliable information on VR immediately before cardioversion for the purposes of this substudy, but in a retrospective approach this is not feasible. Comprehensive data on specific doses of various antiarrhythmic medications used before cardioversion was not collected, since the wide variability in drugs and their dosages is very difficult to report.

Table IV. Success, complications, and early recurrences after ECV according to VR during AF in patients with no rhythm or rate control therapy before ECV (1,189 ECVs in 748 patients).

	VR ≤ 60	60 < VR < 160	VR ≥ 160	*P* value
No. of ECVs	22	1115	52	
No. of patients	20	715	41	
Success rate of ECV	20 (90.9)	1085 (97.0)	52 (98.1)	0.212
Recurrence of AF within 30 days[a]	1 (5.0)	106 (9.8)	5 (9.6)	0.946
Asystole (> 5 s)	0 (0.0)	13 (1.2)	0 (0.0)	1.000
Bradycardia (< 40 bpm)	0 (0.0)	5 (0.5)	0 (0.0)	1.000
Stroke	0 (0.0)	3 (0.3)	0 (0.0)	1.000
Other embolus	0 (0.0)	1 (0.1)	0 (0.0)	1.000
Death within 30 days	0 (0.0)	0 (0.0)	0 (0.0)	–

Values are presented as *n* (%).
[a]Only successful ECVs were included in the analysis: *n* = 1157 (VR ≤ 60: *n* = 20; 60 < VR < 160: *n* = 1,085; VR ≥ 160: *n* = 52).
AF = atrial fibrillation; bpm = beats per minute; ECV = electrical cardioversion; VR = ventricular rate.

Conclusions

Our large real-world multicenter study showed that ECV of acute AF is an effective procedure and VR during AF does not affect its efficacy, the maintenance of sinus rhythm, or the incidence of bradycardic, thromboembolic, or other complications during 30-day follow-up after ECV. Low VR is predominately observed in male patients, while high VR was a feature related to a shorter history of AF and high alcohol intake.

Acknowledgements

The authors thank our study co-ordinator Tuija Vasankari, RN, for her input in data and study management. Acknowledgements to clinical investigators for the collection of the data by center: Turku University Hospital, Turku: I. Nuotio, T. Grönberg, T. Vasankari, A. Karmi, K.E.J. Airaksinen. Satakunta Central Hospital, Pori: M. Ampio, K. Ruuhijärvi, A. Ylitalo. Kuopio University Hospital, Kuopio: M. Nikkinen, P. Autere, E. Parikka, T. Rautiainen, S. Rissanen, M.-L. Sutinen, M. Tuhkalainen, J.E.K. Hartikainen.

Funding: The Finnish Foundation for Cardiovascular Research, Helsinki, Finland; Clinical Research Fund (EVO) of Turku University Hospital, Turku, Finland.

Declaration of interest: The authors report no conflicts of interest.

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