CARDIOVASCULAR MEDICINE

Perceived heart rhythm in relation to ECG findings after direct current cardioversion of atrial fibrillation

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Objective: To investigate the agreement between perceived heart rhythm and the ECG-registered heart rhythm, as well as between symptoms and the ECG after direct current (DC) cardioversion of atrial fibrillation (AF).

Methods: Consecutive patients with symptomatic AF subjected to DC cardioversion were interviewed about perceived heart rhythm and symptoms one week after restoration of sinus rhythm (SR). An ECG was obtained after the interview. A chance-corrected measure of agreement was calculated by using Cohen's κ test.

Results: 356 patients were enrolled. One week after successful cardioversion 160 patients considered their rhythm to be regular and 222 ECGs showed SR. 130 patients considered their heart rhythm to be regular in agreement with ECG in SR ($\kappa = 0.34$, 95% confidence interval (CI) 0.24 to 0.44), indicating a fair agreement. At the same time 59 patients perceived AF and 134 ECGs showed AF. Thirty eight patients perceived AF, in agreement with AF found on their ECG ($\kappa = 0.13$, 95% CI 0.02 to 0.25), a poor agreement. 141 of 356 patients reported improvement of symptoms in agreement with SR on their ECG ($\kappa = 0.26$, 95% CI 0.15 to 0.36), indicating fair agreement. Perceived SR and improvement of symptoms were strongly associated ($n = 129$; $p < 0.001$).

Conclusion: Agreement between perceived heart rhythm and ECG, as well as between improvement of symptoms and SR recorded on the ECG, is no more than poor to fair after successful cardioversion of patients with persistent AF. The association between perceived SR and improvement of symptoms is strong. These findings support the need for objective criteria to select patients who would benefit most from rhythm control. They also support the need for further studies on quality of life of patients with AF, with due attention paid to patients' perception of their cardiac rhythm.

Atrial fibrillation (AF) is the most common sustained cardiac arrhythmia and its prevalence increases with age.¹ AF may cause disabling symptoms, as well as increasing the risk of thromboembolic events.² AF may also be asymptomatic.^{3–4} Earlier studies have shown a reduced quality of life, even among patients described as asymptomatic, especially their general health and global life satisfaction.⁵ Current treatment recommendations for rate or rhythm control highly depend on the symptoms.⁶ The AFFIRM (Atrial Fibrillation Follow-up Investigation of Rhythm Management), RACE (Rate Control Versus Electrical Cardioversion) and STAF (Strategies of Treatment of Atrial Fibrillation) trials found no difference in quality of life between the rhythm and rate control groups.^{7–11} The extent to which patient consciousness of AF influences the perception of symptoms or quality of life has not been evaluated.

In this study, we investigated the agreement between perceived heart rhythm and that recorded on ECG, as well as between improvement of symptoms and the ECG, one week after successful direct current (DC) cardioversion of patients with persistent AF. We also evaluated the association between improvement of symptoms and perceived heart rhythm.

METHODS

Consecutive patients referred to the Cardiology Department of South Hospital in Stockholm, Sweden, with symptomatic persistent AF (atrial flutter excluded) for more than one and less than 12 months, who underwent successful DC cardioversion, were prospectively enrolled in this study. Exclusion criteria for cardioversion were poorly controlled congestive heart failure, hyperthyroidism, and myocardial

infarction or cardiac surgery within the previous two months. All patients underwent a complete medical history, physical examination and ECG. Records including available ECGs were reviewed for all patients. All patients underwent transthoracic echocardiography before cardioversion. Warfarin treatment, to obtain an international normalised ratio between 2.1–3.0, was prescribed to all patients for at least three weeks before and four weeks after cardioversion. No change in drug treatment was allowed between cardioversion and a follow-up visit one week after cardioversion; however, in case of bradycardia < 50 beats/min, the dose could be reduced.

One week after cardioversion, the patients were asked two questions by the same nurse, who also completed a form with the answers. The first question was "Do you believe that your heart rhythm is regular or in atrial fibrillation?" Eligible alternatives were "regular", "atrial fibrillation" and "I don't know".

To evaluate whether symptoms experienced before cardioversion had improved, the second question was "Do you feel better, worse or not different today, compared with before the cardioversion?" Eligible alternatives were "better", "worse" and "not different".

The same nurse thereafter recorded a 12-lead resting ECG. This was followed by a visit to the patient's physician.

For logistic reasons, some patients were also scheduled for a later visit to their physician after cardioversion. In this

Abbreviations: AF, atrial fibrillation; AFFIRM, Atrial Fibrillation Follow-up Investigation of Rhythm Management; DC, direct current; EF, ejection fraction; RACE, Rate Control Versus Electrical Cardioversion; SR, sinus rhythm; STAF, Strategies of Treatment of Atrial Fibrillation

subgroup of patients the same procedure was repeated four weeks after cardioversion.

Statistical analysis

Continuous variables are given as mean (SD). We used Cohen's κ test to measure the agreement between perceived and ECG-recorded heart rhythm, as well as between symptoms and the ECG. We also used the suggested interpretation of agreement for different values of κ statistics (table 1), with a maximum of 1 when agreement is perfect and 0 indicating no agreement better than chance.¹²

We used Pearson's χ^2 test and, for small numbers, Fisher's exact test to measure the association between perceived heart rhythm and symptoms. A value of $p < 0.05$ was considered significant. Calculations were performed with the statistical computer package STATISTICA V.7.0 (StatSoft Inc, Tulsa, Oklahoma, USA).

Our sample size calculation was based on the assumption that about 70% of the patients would be in sinus rhythm (SR) one week after cardioversion and 30% would be in AF. Of the 30% reverting to AF, 15% were expected to be asymptomatic. We also expected that about 30% of the patients would be unsure of their heart rhythm. With $\alpha = 0.05$ and $\beta = 0.20$, a total of 118 patients were required for each answer—that is, regular heart rhythm, atrial fibrillation, and I don't know. Thus, 356 patients were enrolled.

Ethics

The study was discussed with and approved by the chairman of the ethics committee of Karolinska Institute, and all patients gave their informed consent to participate.

RESULTS

Baseline characteristics

Patients ($n = 356$) with persistent symptomatic AF and whose elective DC cardioversion was successful were prospectively enrolled in the study. Table 2 summarises clinical data and drug treatment at baseline.

Perceived heart rhythm and ECG findings

At one week after restoration of SR, 356 patients were seen in the outpatient department. In answering the first question, "Do you believe that your heart rhythm is regular or in atrial fibrillation", 160 patients (45%) thought that they had SR, 59 patients (17%) believed that they had AF, and 137 patients (38%) did not know. The ECG showed SR in 222 patients (62%) and AF in 134 patients (38%). In 130 patients who perceived SR, the ECG also showed SR ($\kappa = 0.34$, 95% confidence interval (CI) 0.24 to 0.44), indicating fair agreement (table 3).

We also analysed subgroups of patients with lone AF, a known duration of AF, valvular heart disease, ejection fraction (EF) $< 40\%$, EF $> 40\%$ and a history of hypertension. In the subgroup with lone AF, the κ value indicated moderate agreement between perceived SR and ECG, whereas the κ value indicated fair agreement in all other subgroups.

Table 1 Suggested interpretation of agreement for different values of κ statistic¹²

κ statistic	Strength of agreement
<0.20	Poor
0.21–0.40	Fair
0.41–0.60	Moderate
0.61–0.80	Good
0.81–1.00	Very good

Table 2 Baseline patient characteristics and drug treatment

Men	257 (72%)
Age (years)	68.0 (11.1)
AF duration (months)	3.4 (1.8)
Hypertension	187 (52%)
Ischaemic heart disease	54 (15%)
Corrected thyroid disease	24 (7%)
Diabetes	35 (10%)
Asthma/COPD	13 (4%)
Valvular heart disease	73 (21%)
Lone AF*	115 (32%)
LA dimension (mm)	45.3 (5.9)
LVEDD (mm)	51.3 (6.8)
Ejection fraction (%)	46.4 (9.7)
β blocker (class II)	236 (66%)
Sotalol	92 (26%)
Amiodarone	8 (2%)
Disopyramide	8 (2%)
Flecainide	3
Verapamil/diltiazem	7 (2%)
ACE inhibitor	145 (41%)

Values are expressed as mean (SD) or number (%) of patients.

*Defined as the absence of any of the above mentioned diseases.

ACE, angiotensin-converting enzyme; AF, atrial fibrillation; COPD, chronic obstructive pulmonary disease; LA, left atrial; LVEDD, left ventricular end diastolic dimension.

Thirty eight of the 59 patients who thought that they had AF were found to have AF on their ECG ($\kappa = 0.13$, 95% CI 0.02 to 0.25), indicating poor agreement.

Symptoms in relation to ECG recording

In answering the second question, "Do you feel better, worse or not different today, compared with before the cardioversion", 190 patients (53%) stated that they felt better, 23 (6%) felt worse and 143 (40%) felt no difference. Of patients who felt better, 141 were in SR on their ECG ($\kappa = 0.26$, 95% CI 0.15 to 0.36), indicating fair agreement (table 3). Of those who felt worse or not different, 85 had ECGs showing AF ($\kappa = 0.25$, 95% CI 0.14 to 0.34), also indicating fair agreement.

Perceived heart rhythm and symptoms

To evaluate to what extent perception of heart rhythm influenced symptoms, we evaluated the association between these two parameters. Associations between perceived SR and improvement in symptoms ($n = 129$, $p < 0.001$) and between perceived AF and worsened or no difference in the symptoms ($n = 37$, $p = 0.04$) (table 4) were strong.

Changes over time

Four weeks after cardioversion, a subgroup of patients ($n = 93$) were asked the same questions. In this subgroup, agreement between heart rhythm and the ECG and between symptoms and the ECG at one week after cardioversion did not differ from the total study population. At this second occasion, 52 patients (56%) were in SR and 41 (44%) had AF on the ECG. SR was perceived by 39 patients, who also were in SR on their ECGs ($\kappa = 0.48$, 95% CI 0.30 to 0.67), indicating moderate agreement. Forty-three patients who felt better also were in SR on their ECGs ($\kappa = 0.42$, 95% CI 0.23 to 0.61), indicating moderate agreement. Perceived SR and improvement of symptoms were strongly associated ($n = 39$; $p < 0.001$).

DISCUSSION

In the present study we have shown that in patients with persistent symptomatic AF who have been successfully

Table 3 Agreement between perceived heart rhythm and ECG and between symptoms and ECG one week after direct current cardioversion (n = 356)

Rhythm on ECG	Perceived heart rhythm			Symptoms		
	SR (n = 160)	AF (n = 59)	Unsure (n = 137)	Better (n = 190)	Worse (n = 23)	Not different (n = 143)
SR (n = 222)	130*	21	71	141†	11	70
AF (n = 134)	30	38‡	66	49	12§	73§

*Calculated $\kappa = 0.34$ (95% CI 0.24 to 0.44), fair agreement; †calculated $\kappa = 0.26$ (95% CI 0.15 to 0.36), fair agreement; ‡calculated $\kappa = 0.13$ (95% CI 0.02 to 0.25), poor agreement; §calculated $\kappa = 0.25$ (95% CI 0.14 to 0.34), fair agreement.
AF, atrial fibrillation; SR, sinus rhythm.

treated by DC cardioversion, agreement was no more than fair between the perceived and the ECG-recorded heart rhythm one week after cardioversion. Similarly, agreement was fair between improvement of symptoms and SR in the resting ECG. However, perceived SR and improvement of symptoms were strongly associated. At four weeks after cardioversion in a subgroup of patients agreement was moderate between perceived heart rhythm and the ECG, as well as between improvement of symptoms and the ECG. Perceived SR and improvement of symptoms were also strongly associated.

The AFFIRM, RACE and STAF trials all found no difference in quality of life between the rhythm control and rate control groups.^{7–11} One concern has been that these studies were analysed by an intention-to-treat approach and that this might have confounded the results concerning quality of life. None of these trials stated to what extent the patients were aware of their heart rhythm when answering the questionnaires. Earlier studies on the quality of life of patients with AF report significantly lower values than for their healthy controls.^{13–14} It is possible that patients are more inclined to report symptoms when made aware of their ECG findings and that this may decrease their overall perception of well-being. In an attempt to eliminate this risk we asked our patients about their perceived heart rhythm and their symptoms before their ECG was recorded.

Perceived heart rhythm and ECG findings

Our results show no more than poor to fair agreement between perceived and ECG heart rhythm, for both patients with SR and patients with AF. To our knowledge no comparable data are available. We also analysed six subgroups of patients (lone AF, known duration of AF, valvular heart disease, EF < 40%, EF > 40% and a history of hypertension) to identify groups of patients with a better agreement between perceived heart rhythm and the ECG. Agreement was only fair in five of these groups and was moderate in patients with lone AF, which suggests that patients with fewer symptoms due to other diseases can perceive their actual heart rhythm to a greater extent.

Table 4 Agreement between perceived heart rhythm and symptoms one week after cardioversion (n = 356)

Perceived heart rhythm	Symptoms		
	Better (n = 190)	Worse (n = 23)	Not different (n = 143)
SR (n = 160)	129**	9	22
AF (n = 59)	22	5*	32*
Unsure (n = 137)	39	9	89

*p = 0.04; **p < 0.001.

AF, atrial fibrillation; SR, sinus rhythm.

Symptoms in relation to ECG findings

We found poor to fair agreement between symptoms and the ECG-recorded rhythm, in both patients with SR and those with AF. Many different factors are thought to cause symptoms of AF such as loss of normal atrioventricular synchronisation that reduces cardiac output by 15–25%, notably irregular RR intervals, uncontrolled ventricular rates, concomitant heart disease, drug treatment, and individual patient perception.^{15–17} Recognising symptoms caused by AF is difficult in individual patients. One earlier study found about 30% of patients with persistent AF to be asymptomatic. In that investigation the presence of valvular heart disease was an independent factor related to symptoms, but neither an irregular heart rate nor impaired left ventricular function was associated with symptoms. Those authors concluded that individual perception and adjustment of lifestyle may be major determinants for the development of symptoms in AF.¹⁸ In a recent study by Hindricks *et al*,¹⁹ asymptomatic episodes of AF increased after radiofrequency catheter ablation treatment and analysis of patient characteristics and arrhythmia patterns did not identify a specific subset of patients at high risk for the development of asymptomatic AF. These difficulties in defining individual symptoms caused by AF reduce our ability to identify patients who would benefit symptomatically from rhythm control treatment.

One possible explanation for our findings of overall poor agreement between symptom improvement and the ECG findings is that the perception of individual well-being is dominated by symptoms related to other circumstances than AF itself. Several studies on the effect of AF on quality of life report significantly lower quality in patients with persistent AF than in healthy controls. In our study, we found poor agreement between perceived heart rhythm and ECG findings; the difficulty patients had in perceiving their heart rhythm might also have influenced their experience of other symptoms. A patient with perceived AF is more likely to answer the question about symptoms with “worse” or “not different”, irrespective of ECG findings. This is also reflected by our findings of the highly significant association between perceived heart rhythm and improvement of symptoms. Accordingly, further studies of patients with AF are needed that use standardised methods to assess quality of life, including the impact of patient perception of heart rhythm.

Changes over time

A subgroup of patients were again questioned about perceived heart rhythm and symptoms four weeks after cardioversion. These patients did not differ from the rest of the study population one week after cardioversion in their differences between perceived heart rhythm and the ECG or between symptoms and the ECG. In this subgroup, we found a trend towards better agreement between perceived heart rhythm and the ECG and between improvement of symptoms and the ECG. One possible explanation for this is that these patients were informed of their heart rhythm at one week

and therefore were more likely to correctly judge their heart rhythm at four weeks. Another possible explanation is delayed recovery of mechanical and hormonal atrial function, which in several studies has been seen to take up to four weeks.^{20,21} This is supported by Wozakowska-Kaplon and Opolski,²² who reported significant clinical improvement as late as 30 days after restoration of SR. This is of interest, as symptom improvement during the first days after cardioversion often is a determining factor in deciding whether a patient should undergo repeat cardioversion in the case of early relapse.

Study limitations

In this study we have used a standard number of simple questions. Thus, our questions are not validated for reliability and validity. However, our purpose was to validate the patient's perceived heart rhythm by using the ECG as the reference standard.

The subgroup of patients who were evaluated again four weeks after cardioversion was not defined prospectively, and our findings in this group must therefore be interpreted with caution. However, these patients were selected merely for logistic reasons. Moreover, this subgroup of patients did not differ from the total study population one week after cardioversion.

Some patients might have learned to feel their own pulse, thereby increasing their ability to judge their heart rhythm correctly. If so, the agreement between perceived and ECG heart rhythm would have been even lower.

Conclusions

Agreement between perceived and ECG-recorded heart rhythm is no more than poor to fair one week after successful DC cardioversion of patients with persistent symptomatic AF. Agreement is fair between improvement of symptoms and ECG-recorded SR. The association between perceived SR and improvement of symptoms is strong. These findings support the need for objective criteria to select patients who would benefit most from rhythm control. They also support the need for further studies on the quality of life of patients with AF, with due attention given to the patients' perception of their cardiac rhythm.

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