CorSalud 2014 Oct-Dec;6(4):280-287

CorSalud

Cuban Society of Cardiology

Original Article

Cardiocentro Ernesto Che Guevara Santa Clara Cuba

Predictors of success of electrical cardioversion for atrial fibrillation

Marleny Cruz Cardentey[a], MD; Taimara Pérez Rivera[b], MD; and Annerys Méndez Rosabal[a], MD

[a] Department of Arrhythmia and Pacemaker. Hermanos Ameijeiras Clinical-Surgical Hospital. Havana, Cuba.
[b] Department of Cardiology. Enrique Cabrera Clinical-Surgical Hospital. Havana, Cuba.

Este artículo también está disponible en español

ARTICLE INFORMATION

Received: April 15, 2014
Accepted: June 10, 2014

Competing interests
The authors declare no competing interests

Acronyms
AF: atrial fibrillation
ECV: electrical cardioversion
IST: interventricular septal thickness
LVEDD: left ventricular end-diastolic diameter
LVEF: left ventricular ejection fraction
interventricular septal thickness (IST

On-Line Versions:
Spanish - English

✉ *M Cruz Cardentey*
Hospital Hermanos Ameijeiras
San Lázaro 701, e/ Belascoaín y Marqués González. Centro Habana
CP 10300. La Habana, Cuba.
E-mail address:
marleny.cruz@infomed.sld.cu

ABSTRACT

Introduction: Electrical cardioversion is an effective therapeutic procedure to restore sinus rhythm in atrial fibrillation, and its success has been related to different variables.

Objective: To relate clinical, electrical and echocardiographic variables to the success of electrical cardioversion for atrial fibrillation and to the amount of energy used to restore sinus rhythm.

Method: A prospective longitudinal study was conducted in 82 patients with atrial fibrillation who were treated with elective electrical cardioversion.

Results: Electrical cardioversion was successful in 81.7% of patients. Heart failure (p=0.000), mitral valve disease (p=0.001), previous arrhythmic events (p=0.005), increased time to progression (p=0.019), increased left ventricular telediastolic diameter (p=0.000), and increased diameter, area and pressure of the left atrium (p=0.000, p=0.008, p=0.000, respectively), were associated with a decrease in the success of the shock. Left ventricular ejection fraction was the only independent predictor of success (OR 2.1; 95% CI, p=0.048). The use of a higher amount of energy was related to previous arrhythmic events (p=0.000), decreased left ventricular ejection fraction (p=0.000), older age (p=0.037), increased time to progression (p=0.02), increased left ventricular diameter (p=0.000), increased diameter, area and pressure of the left atrium (p=0.000, p=0.000 and p=0.000, respectively) and increased area of the right atrium (p=0.016).

Conclusions: The left ventricular ejection fraction is an independent predictor of the success of electrical cardioversion for atrial fibrillation. The presence of biatrial remodeling, left ventricular dysfunction, previous arrhythmic events and a long progression require higher amounts of energy to restore sinus rhythm.

Key words: Atrial fibrillation, Electrical cardioversion, Left ventricular dysfunction

Factores predictores de éxito de la cardioversión eléctrica en la fibrilación auricular

RESUMEN

Introducción: La cardioversión eléctrica es una terapeútica efectiva para restaurar el ritmo sinusal en la fibrilación auricular y su éxito se ha relacionado con diferentes variables.

Objetivo: Relacionar variables clínicas, eléctricas y ecocardiográficas con el éxito de la cardioversión eléctrica en la fibrilación auricular y con la energía útil empleada para restaurar el ritmo sinusal.
Método: Se realizó un estudio longitudinal y prospectivo en 82 pacientes con fibrilación auricular tratados con cardioversión eléctrica electiva.
Resultados: La cardioversión eléctrica fue exitosa en el 81,7 % de los pacientes. La insuficiencia cardíaca (p=0.000), la valvulopatía mitral (p=0.001), los episodios arrítmicos previos (p=0.005), el incremento del tiempo de evolución (p=0.019), del diámetro telediastólico del ventrículo izquierdo (p=0.000), y del diámetro, el área y la presión de la aurícula izquierda (p=0.000, p=0.008, p=0.000, respectivamente), se asociaron con una disminución del éxito del choque. La fracción de eyección del ventrículo izquierdo es el único predictor independiente de éxito (OR 2,1; IC 95 %, p=0.048). Con una mayor energía útil se relacionaron los episodios previos (p=0.000), la disminución de la fracción de eyección del ventrículo izquierdo (p=0.000), la mayor edad (p=0.037), los incrementos del tiempo de evolución (p=0.02), del diámetro ventricular izquierdo (p=0.000), del diámetro, el área y la presión de la aurícula izquierda (p=0.000, p=0.000 y p=0.000, respectivamente) y del área de la aurícula derecha (p=0.016).
Conclusiones: La fracción de eyección del ventrículo izquierdo es un predictor independiente del éxito de la cardioversión eléctrica en la fibrilación auricular. La presencia de remodelado biauricular, de disfunción ventricular izquierda, de episodios arrítmicos previos y de una larga evolución, requieren niveles superiores de energía para restaurar el ritmo sinusal.
Palabras clave: Fibrilación auricular, Cardioversión eléctrica, Disfunción ventricular izquierda

INTRODUCTION

Atrial fibrillation (AF) is the most common tachyarrhythmia, and is considered an independent predictor of mortality and ischemic cerebrovascular disease. Approximately 1% of the adult population suffers from it with ratios that vary from 0.1% in those under 55 and 9% in those over 80 years. Its true incidence is underestimated because of the high percentage that is asymptomatic and whose diagnosis is a finding[1,2]. It accounts for 5% of total cardiovascular admissions and for the third part of admissions due to an arrhythmic cause, so it is now regarded as a macrosocial problem[3].

AF has a cumulative effect and the electrical, contractile and structural atrial remodeling self-perpetuates it. Each new episode increases the frequency and duration of the paroxysms, and decreases the effectiveness of antiarrhythmic drugs and electrical cardioversion (ECV).

The immediate success rate of ECV in AF ranges from 50-90%, according to the different series, and it has been associated with different variables such as age, body mass index, underlying heart disease, duration, previous episodes, use of antiarrhythmic drugs, atrial remodeling, ventricular function, and energy and type of shock wave[4-6]. Despite being a safe procedure, serious proarrhythmic, thromboembolic and anesthetic complications have been reported[7]; for this reason, success probabilities of the procedure must be judiciously and individually assessed.

This research was conducted with the aim of relating clinical, electrical and echocardiographic variables to the success of ECV in AF and to the useful energy required to restore sinus rhythm.

METHOD

A descriptive, longitudinal and prospective study was conducted at the Cardiology office of Hermanos Ameijeiras Clinical-Surgical Hospital, from April 2008 to April 2010. The sample comprised 82 patients with AF who underwent elective ECV, so emergency ECV was excluded.

In a medical encounter previous to the elective ECV, an interview, physical examination, electrocardiogram and echocardiogram were conducted, in which clinical and echocardiographic variables of interest such as sex, age, color of skin, underlying heart disease, duration of AF episodes, use of antiarrhythmic drugs, ventricular response, left ventricular ejection fraction (LVEF), left ventricular end-diastolic diameter

(LVEDD), interventricular septal thickness (IST), and diameter, area and pressure of the right and left atria were obtained.

ECV was performed under anesthesia with propofol at doses of 1-2 mg/kg, the vanes in the standard position and with biphasic waveform type. The energy levels were increasing, with values between 100 and 360 Joules, with a maximum of 3 shocks.

Successful ECV was considered as the presence of post-procedure sinus rhythm and its permanence during the first 30 minutes. Useful energy was classified as the energy used in the successful shock.

LVEF was determined by the method of Teichholz, and in cases with ventricular asynergy the area-length method was used. LVEDD, IST and diameter of the left atrium were obtained in parasternal long axis. The diameter of the right atrium and the area of both atria were obtained in the four-chamber view. Atrial pressures were calculated by the formulas:

- Right atrium pressure = E/E' * 1.76 - 3.7
- Left atrial pressure = E/E' * 1.24 + 1.91

E wave velocity was obtained by pulsed Doppler in mitral and tricuspid flows, as appropriate. The E' wave velocity was acquired by tissue Doppler of the lateral annulus of the mitral and tricuspid valves, as appropriate.

Patients with AF of more than 48 hours or doubtful duration were anticoagulated with warfarin sodium, 3 weeks before and 4 weeks after the ECV (INR between 2.0 - 3.0); antiarrhythmic drugs were also used for a time longer than 3 months after the shock. In patients with AF of less than 48 hours duration only heparin sodium (50 mg) was used during the procedure, and the use of antiarrhythmic drugs was optional.

The Student t test for comparison of means was used to determine the association between quantitative variables and the success of ECV and the χ^2 test for qualitative variables. In the univariate analysis the most significant variables were taken and a multivariate analysis of logistic regression was made. ANOVA procedure was used to compare the means of the useful energy with the qualitative variables and the Pearson correlation coefficient to determine the association between useful energy and quantitative variables. A p less than 0.05 was considered significant.

RESULTS

ECV was successful in 81.7% of patients (67/82). The existence of a previous arrhythmic episode was associated with a decrease in ECV success (p = 0.005); unlike sex, skin color, use of antiarrhythmic drugs and ventricular response which did not have any influence (**Table 1**).

The presence of heart failure and mitral valve disease was significantly associated (p = 0.000 and p = 0.001, respectively) with a lower success of shock;

Table 1. Distribution of patients, according to clinical variables and ECV success.

Variables	ECV				p
	Success (67/82)		No success (15/82)		
	Nº	%	Nº	%	
Sex					
Male	48	82,8	10	17,2	0.7
Female	19	79,2	5	20,8	
Skin color					
White	33	80,5	8	19,5	
Black	9	81,8	2	18,2	0.95
Mixed-race	25	83,3	5	16,7	
Previous event					
Yes	31	70,5	13	29,5	**0.005**
No	36	94,7	2	5,3	
AD use					
Yes	5	16,7	25	83,3	0.89
No	1	14,3	6	85,7	
Ventricular response					
High	9	20,0	36	80,0	
Low	15	21,4	55	78,6	0.076
Normal	0	0	12	100	
Associated diseases					
IHD	22	32,8	5	33,3	0.970
HF	2	3,0	6	40,0	**0.000**
HBP	33	49,3	5	33,3	0.391
MVD	8	12,0	8	53,3	**0.001**
DM	14	21,0	3	20,0	0.938
Age (mean)	55,28		61,33		0.078

Caption. IHD: Ischemic heart disease, DM: diabetes mellitus, AD: Antiarrhythmic drugs, HBP: high blood pressure, HF: heart failure, MVD: mitral valve disease.

however, a history of ischemic heart disease, hypertension or diabetes mellitus had no influence. The mean age of patients with successful ECV was lower, but without significant differences, although with a trend (p =0.078).

Table 2 shows that as duration of arrhythmia increases, ECV success decreases (p = 0.019).

Table 2. Distribution of patients, according to progression time and ECV success (n=82).

Progression Time	ECV				Total	
	Success		No success			
	Nº	%	Nº	%	Nº	%
< 48 h	6	7,32	0	0	6	7,32
48 h – 1 m	16	19,51	3	3,66	19	23,17
2 m – 6 m	28	34,15	3	3,66	31	37,8
7 m – 12 m	17	20,73	7	8,54	24	29,27
> 12m	0	0	2	2,44	2	2,44
Total	67	81,71	15	18,29	82	100

Caption. h: hour, m: month
p = 0.019

Table 3. Relation among echocardiographic variables and ECV success.

Variables (means)	ECV		p
	Success	No success	of success
RA diameter (mm)	30,94	35,33	0.116
RA area (cm^2)	12,59	15,53	**0.058**
RA pressure (mmHg)	5,29	6,73	0.141
LA diameter (mm)	35,88	42,66	**0.000**
LA area (cm^2)	17,91	22,67	**0.008**
LA pressure (mmHg)	8,28	12,60	**0.000**
LVEF (%)	61,03	48,47	**0.000**
LVEDD (mm)	45,87	54,87	**0.000**
IST (mm)	11,49	11,47	0.986

Caption. RA: right atrium, LA: left atrium

The mean of diameter, area and pressure of both atria was higher in patients with failed ECV (**Table 3**); but only at the level of the left atrium these measurements showed statistical significance (p = 0.000, p = 0.008 and p = 0.000, respectively). Mean LVEF was statistically higher in individuals with successful ECV (p = 0.000), whereas LVEDD was statistically higher in those without success (p = 0.000). IST showed no differences between both subgroups.

Considering that the sample was limited due to the number of variables under study, those with more significance in the univariate analysis were taken and a logistic regression model was applied, which showed that LVEF was the only independent predictor of ECV success (p = 0.048). For every 1% of LVEF increase, the probability of restoring sinus rhythm increased by 2.1 (**Table 4**).

Table 4. Variables associated to ECV success. Multivariate analysis.

Variables	Coefficient B	p
Age	0,003	0.929
LA area	-0,053	0.665
LA pressure	-0,294	0.113
LVEF	**2,10**	**0.048**
LVEDD	-0,027	0.824
Previous events	-2,2395	0.139
Progression time 48 h - 1 m and 2 m - 6 m	- 14,941	0.921

Caption. LA: left atrium, h: hours, m: months

The mean of useful energy for achieving a successful ECV was significantly higher in patients with a history of a previous arrhythmic episode (p = 0.000); while skin color, sex, antiarrhythmic drugs and ventricular response showed no influence (**Table 5**). As the duration of arrhythmia increases the mean of useful energy for successful ECV also increases (p = 0.02). Between age and useful energy for effective ECV a positive correlation coefficient with statistical significance (p = 0.037) is established; which shows that the older a patient is, the more energy is needed to restore sinus rhythm.

The area of the right atrium (p = 0.016) as well as the diameter (p = 0.000), the area (p = 0.000) and left atrial pressure (p = 0.000), and LVEDD (p = 0.000), establish a positive correlation coefficient with the useful energy (**Table 6**); conversely, a negative coefficient of correlation with LVEF is established, so that the

lower the LVEF, the more energy is required (p = 0.000). The diameter and the pressure of the right atrium and IST did not correlate with the variable under analysis.

Table 5. Correlation of the mean values of useful energy with clinical variables.

Variables	ECV		p
	Median	SD	
Sex			
Female	197,91	58,00	0.436
Male	199,13	51,71	
Skin color			
White	203,65	52,90	0.719
Black	200,00	54,77	
Mixed-race	191,66	54,27	
Previous events			
Yes	222,72	53,32	**0.000**
No	171,05	37,90	
AD use			
Yes	179,16	25,746	0.349
No	202,14	56,102	
Ventricular response			
High	195,00	53,093	0.569
Low	200,00	50,000	
Normal	201,11	54,864	
Progression Time			
< 48 h	175	27,05	**0.02**
48 h – 1 m	189,47	54,20	
2 m – 6 m	193,54	42,3	
7 m – 12 m	210,41	62,5	
> 12m	300	0	
Age	Correlation Coefficient: 0.231		**0.037**

Caption. SD: standard deviation, AD: Antiarrhythmic drugs, h: hours, m: months

DISCUSSION

Anatomical and functional changes in the atrial myocardium during aging, coupled with greater comorbidity in the elderly, justify the high incidence, prevalence and recurrence of AF in that subpopulation, as well as the less effectiveness of therapies used to restore sinus rhythm[8].

Table 6. Correlation of the mean values of useful energy with echocardiographic variables.

Variables	Useful energy	
	Correlation Coefficient	p
RA diameter	0,210	0.059
RA area	0,266	**0.016**
RA pressure	0,216	0.050
LA diameter	0,50	**0.000**
LA area	0,0394	**0.000**
LA pressure	0,532	**0.000**
LVEF	- 0,581	**0.000**
LVEDD	0,487	**0.000**
IST	0,232	0.36

Caption. RA: right atrium, LA: left atrium

In our study the mean age of patients with unsuccessful ECV was higher and with a trend to statistical significance; it was also shown that with increasing age the useful energy to restore the rhythm increases. In the literature reviewed, a cutoff age of 65 years is associated with decreased ECV success, although the significance is lost when applying a logistic regression model[9]. Other authors set the limit at 75 years[10].

Atrial remodeling in heart failure favors the origin and perpetuation of AF. The prevalence of AF in patients with functional class I is 4%, and rises to 50% in patients in functional class IV[11]. In our research the history of heart failure was associated with a decrease in the success of ECV, a result consistent with other authors[12].

Mitral valve disease produces anatomical and electrophysiological changes in the left atrium that favor reentry and abnormal automaticity with fibrillatory conduction; therefore they are the justification for a lesser success of ECV in this subgroup. The latest research assessing the influence of mitral valve disease in ECV success are different[5,13,14] and these differences are justifiable by the disparity among the samples and by the lack of assessment regarding the severity of the

valve disease.

AF has a cumulative effect and perpetuates itself. An atrium is more vulnerable to fibrillation if it has had a previous episode. In turn, the future episode will be more durable, more difficult to treat with cardioversion techniques, and more vulnerable to recurrence and chronicity. A vicious circle is established: AF triggers AF[15]. In our series, a history of a previous episode of AF was associated with a lower success of CVE and with a more useful energy to restore sinus rhythm, which is consistent with other authors[12,13].

Antiarrhythmic drugs modify the electrophysiological properties of myocardial cells and annihilate the mechanisms for the genesis of AF. Its use prior to ECV (especially in arrhythmias with more than 48 hours of progression, with remodeled atria and prior arrhythmic events), increases the shock effectiveness in the short and long terms. Several studies have identified the use of antiarrhythmic drugs as an independent predictor of successful ECV[16,17]. The lack of significance in our study could be related to the small sample volume and the non-uniformity in the type of drug, dose and time of use prior to the shock.

The electrical remodeling is established after 48 hours of AF onset, then after the arrhythmia has perpetuated, the contractile and structural remodeling is successively established. Therefore, the longer the duration of AF, the greater the electrical and histological disorder which favors its perpetuation and the reversion techniques become less effective[15,18]. Several studies have associated long-standing AF with less success in ECV[4,6,9]. Kuppahally *et al*.[13] found that a short duration of AF (within 3 days), is a determining factor in the success of the procedure (OR: 1.361, p = 0.003). In our research, with increasing duration of arrhythmia the success of CVE decreases and the mean of the useful energy required to restore sinus rhythm increases.

According to results of the Framingham study, the incidence of heart failure among subjects with AF was 33 per 1000 person-years, and the incidence of AF among those suffering from heart failure was 54 per 1000 person-years. Individuals with AF or heart failure who secondarily develop the other disease have a worse prognosis, with increased mortality[11]. A vicious circle is established between the two conditions[19]. For this reason, LVEF is a useful tool to assess the potential risk of arrhythmia and the feasibility to revert it to sinus rhythm.

In our research, the mean LVEF was statistically higher in individuals with successful ECV and was the only independent predictor of procedural success. For every 1% of LVEF increase the probability of restoring sinus rhythm increased by 2.1. Similarly, the decrease in LVEF was associated with an increase of the useful energy for the procedure to be considered successful.

Many authors relate the short and long term ECV failure with a decrease in LVEF, and consider this variable as one of the most relevant indicators in the assessment of cases for this type of treatment[20]. For Elhendy *et al*.[6], the decrease in LVEF, within the remaining echocardiographic variables, was the only independent predictor of procedural success (OR 1.15, p = 0.04). Others have shown no relationship, and justify it with the absence, in their series, of severely depressed ventricular function (LVEF <20%)[5,13].

The increase in LVEDD will express a further deterioration of left ventricular systolic function and it explains, in our series, that with its increase the success of ECV decreases and that a higher useful energy will be required to restore sinus rhythm. Certain research share similar results[20,21]; others are different[5] and they explain it by the absence of patients with large left ventricular dilatation.

The remodeled atrial expands and its pressure increases, the lateral and longitudinal diameter increases, and consequently its area and volume. Quantifying these variables by echocardiography is a useful tool to assess the extent of atrial remodeling and the feasibility of reverting to sinus rhythm. Although changes are potentially reversible after restoration of sinus rhythm, once important anatomical alterations have been established, a point of no return has been reached, where restoring the sinus rhythm and keeping it is practically a chimera[18,22].

The mean diameter, area and left atrial pressure in patients with failed ECV was statistically higher, a significance that is lost in multivariate analysis. Among these variables and the mean of useful energy a positive correlation coefficient was established. As the left atrium dilates and increases its pressure, more energy is required to achieve an effective ECV.

Other authors[23,24] report similar results; however, recent studies show discrepancies and suggest not to defer ECV by relying only on left atrial dilatation[13,17]. Other studies with similar findings have as bias that only in a small proportion of the sample there is a marked growth of the left atrium[4,5,25].

The diameter, area, and right atrial pressure were not related to the success of ECV. Only an increase in the area of the right atrium was significantly associated with a higher useful energy. The specific molecular, cellular and electrophysiological properties of the left atrium explain its more crucial relationship in the genesis of AF, while the right atrium is more involved in the atrial flutter[26].

CONCLUSIONS

ECV is an effective method to restore sinus rhythm in AF. Heart failure, mitral valve disease, previous arrhythmic events, left ventricular dysfunction, biatrial remodeling and longstanding progression of AF is associated with a less successful ECV and higher useful energy. In these conditions it is advisable to start with higher energy levels to decrease the number of shocks and the total energy stored. LVEF was the only independent predictor of success.

REFERENCES

1. Go AS, Hylek EM, Phillips KA, Selby JV, Henault LE , Chang Y, *et al*. Prevalence of diagnosed atrial fibrillation in adults: national implications for rhythm management and stroke prevention: the anticoagulation and risk factors in atrial fibrillation (ATRIA) study. JAMA. 2001;285(18):2370-5.
2. Kannell WB, Wolf PA, Benjamin EJ, Levy D. Prevalence, incidence, prognosis and predisposing conditions for atrial fibrillation: population-based estimates. Am J Cardiol. 1998;82(7 Suppl 1):2-9.
3. Le Heuzey JY, Paziaud O, Piot O, Said MA, Copie X, Lavergne T, *et al*. Cost of care distribution in atrial fibrillation patients: the COCAF study. Am Heart J. 2004;147(1):121-6.
4. Arnar DO, Danielsen R. Factors predicting maintenance of sinus rhythm after direct current cardioversion of atrial fibrillation and flutter: a reanalysis with recently acquired data. Cardiology. 1996; 87(3):181-8.
5. Blich M, Edoute Y. Electrical cardioversion for persistent or chronic atrial fibrillation: Outcome and clinical factors predicting short and long term success rate. Int J Cardiol. 2006;107(3):389-94.
6. Elhendy A, Gentile F, Khandheria BK, Hammill SC, Gersh BJ, Bailey KR, *et al*. Predictors of unsuccessful electrical cardioversion in atrial fibrillation. Am J Cardiol. 2002;89(1):83-6.
7. Cakulev I, Efimod IR, Waldo AL. Cardioversion: Past, present, and future. Circulation. 2009;120(16): 1623-32.
8. Psaty BM, Manolio TA, Kuller LH, Kronmal RA, Cushman M, Fried LP, *et al*. Incidence of and risk factors for atrial fibrillation in older adults. Circulation. 1997;96(7):2455-61.
9. Fumagalli S, Boncinelli L, Bondi E, Caleri V, Gatto S, Di Bari M, *et al*. Does advanced age affect the immediate and long-term results of direct-current external cardioversion of atrial fibrillation? J Am Geriatr Soc. 2002;50(7):1192-7.
10. Berry C, Rae A, Taylor J, Brady AJ. Atrial fibrillation in the elderly. Br J Cardiol. 2003;10(5):373-8.
11. Wang TJ, Larson MG, Levy D, Vasan RS, Leip EP, Wolf PA, *et al*. Temporal relations of atrial fibrillation and congestive heart failure and their joint influence in mortality: The Framingham Heart Study. Circulation. 2003;107(23):2920-5.
12. Disertori M, Lombardi F, Barlera S, Latini R, Maggioni AP, Zeni P, *et al*. Clinical predictors of atrial fibrillation recurrence in the Gruppo Italiano per lo Studio della Sopravvivenza nell'Infarto Miocardico-Atrial Fibrillation (GISSI-AF) trial. Am Heart J. 2010;159(5):857-63.
13. Kuppahally SS, Foster E, Shoor S, Steimle AE. Short-term and long-term success of electrical cardioversion in atrial fibrillation in managed care system. Int Arch Med [Internet]. 2009[citado 9 Feb 2014]; 2:39. Disponible en: http://www.intarchmed.com/content/pdf/1755-7682-2-39.pdf
14. Bailey GW, Braniff BA, Hancock EW, Cohn KE. Relation of left atrial pathology to atrial fibrillation in mitral valvular disease. Ann Intern Med. 1968; 69(1):13-20.
15. Allessie M, Ausma J, Schotten U. Electrical, contractile and structural remodeling during atrial fibrillation. Cardiovasc Res. 2002;54(2):230-46.
16. Roy D, Talajic M, Dorian P, Connolly S, Eisenberg MJ, Green M, *et al*. Amiodarone to prevent recurrence of atrial fibrillation. Canadian Trial of Atrial Fibrillation Investigators. N Engl J Med. 2000; 342(13):913-20.
17. Capucci A, Villani GQ, Aschieri D, Rosi A, Piepoli MF. Oral amiodarone increases the efficacy of direct-current cardioversion in restoration of sinus rhythm in patients with chronic atrial fibrillation. Eur Heart J. 2000;21(1):66-73.
18. Wijffels MC, Kirchhof CJ, Dorland R, Allessie MA.

Atriall fibrillation begets atrial fibrillation. A study in awake chronically instrumented goats. Circulation. 1995;92(7):1954-68.

19. Crijns HJ, Tjeerdsma G, de Kam PJ, Boomsma F, van Gelder IC, van den Berg MP, *et al*. Prognostic value of the presence and development of atrial fibrillation in patients with advanced chronic heart failure. Eur Heart J. 2006;21(15):1238-45.
20. Dittrich HC, Erickson JS, Schneiderman T, Blacky AR, Savides T, Nicod PH. Echocardiographic and clinical predictors for outcome of elective cardioversion of atrial fibrillation. Am J Cardiol. 1989;63(3):193-7.
21. Frick M, Frykman V, Jensen-Urstad M, Ostergren J, Rosenqvist M. Factors predicting success rate and recurrence of atrial fibrillation after first electrical cardioversion in patients with persistent atrial fibrillation. Clin Cardiol. 2001;24(3):238-44.
22. Hobbs WJ, Fynn S, Todd DM, Wolfson P, Galloway M, Garratt CJ. Reversal of atrial electrical remodelling after cardioversion of persistent atrial fibrillation in humans. Circulation. 2000;101(10): 1145-51.
23. Alt E, Ammer R, Lehmann G, Pütter K, Ayers GM, Pasquantonio J, *et al*. Patient characteristics and underlying heart disease as predictors of recurrent atrial fibrillation after internal and external cardioversion in patients treated with oral sotalol. Am Heart J. 1997;134(3):419-25.
24. Tebbe U, Carlsson J, Seidl K, Jansen W, Schuster HP, Elsner M, *et al*. Cardioversion in atrial fibrillation. Results and complications in 1.152 prospective patients. Study Group of the Working Society of Leading Cardiologic Hospital Physicians. Med Klin (Munich). 1995;90(12):681-7.
25. Roijer A, Meurling CJ, Eskilsson J, Olsson B. Left atrial appendage outflow velocity index is superior to conventional criteria for prediction of maintenance of sinus rhythm after cardioversion. An echocardiographic study in patients with atrial fibrillation of a few months' duration. Scand Cardiovasc J. 2001;35(2):119-24.
26. Jalife J. ¿Por qué es la aurícula izquierda tan importante en el mecanismo de la fibrilación auricular crónica? RIA [Internet]. 2009[citado 9 Feb 2014];1(1):3-26. Disponible en: http://www.ria-online.com/webapp/uploads/15_layouted_ria_riaar001-v10_20091103.pdf