

## 심방세동의 전기적 동율동 전환요법시 전기충격 직후 나타나는 심방 활성화 유형

정성원 · 김영훈 · 신정호 · 김진석 · 박성미 · 손수민  
황교승 · 이수진 · 박희남 · 심완주 · 오동주 · 노영무

### Activation Patterns Following Successful and Unsuccessful DC Cardioversion for Atrial Fibrillation

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#### ABSTRACT

**Background and Objectives** : The mechanism by which atrial fibrillation (AF) electrically converts to sinus rhythm remains undefined. The purpose of this study was to assess in detail the electrograms recorded during cardioversion using direct current (DC) shock. **Subjects and Methods** : In 23 patients with AF (chronic n = 20, paroxysmal n = 3, M : F = 15 : 8, 50 - 70 years old), electrograms were recorded simultaneously from a 20-pole electrode catheters (Duo-deca, DAIG) in the right atrial free wall and the coronary sinus immediately after DC shock given transthoracically. The activation patterns following 45 trials consisting of 23 successful and 22 unsuccessful cardioversion were analyzed. **Results** : Two distinct patterns following successful cardioversion were observed ; either immediate resumption of normal sinus rhythm (n = 5, 21%), or one or two activations immediately after shock preceded normal sinus rhythm (n = 18, 79%). The energy levels of the two patterns were not significantly different (260 J, 250 J, respectively). Four patterns following unsuccessful cardioversion were noted ; unchanged (n = 10, 45%), converted to atrial flutter (n = 4, 18%), production of three or four beats of more coordinated complexes and reverted to AF (n = 5, 22%), and converted to sinus rhythm transiently and reinitiated AF by one or two atrial premature beats (n = 3, 13%). The magnitude of the DC shock applied at these 4 different patterns was 196 J, 240 J, 264 J, and 340 J, respectively in which low energy levels made a simultaneous depolarization of the entire atria unlikely. **Conclusion** : Distinct activation patterns were identified following successful and unsuccessful cardioversion using DC shock for AF. These observations suggest that total depolarization of the entire atria is not a prerequisite for the conversion of AF into sinus rhythm. (Korean Circulation J 2001;31(12):1297-1304)

**KEY WORDS** : Atrial fibrillation ; Electric countershock.

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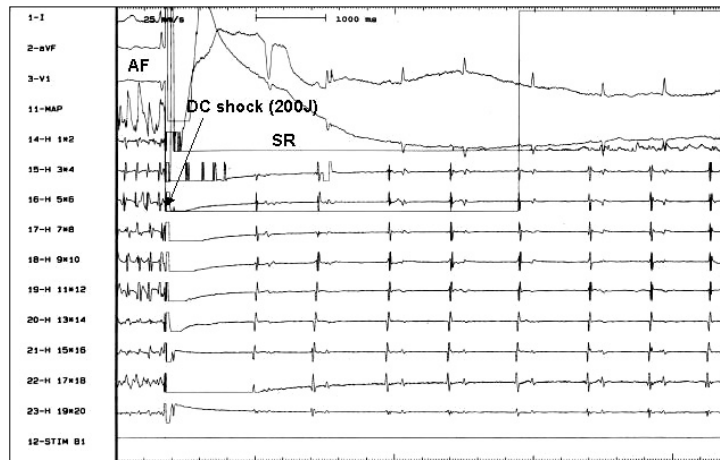
## 서 론

가 45  
가,  
Student's t-test,  $p < 0.05$   
65% 90%<sup>1-6)</sup>  
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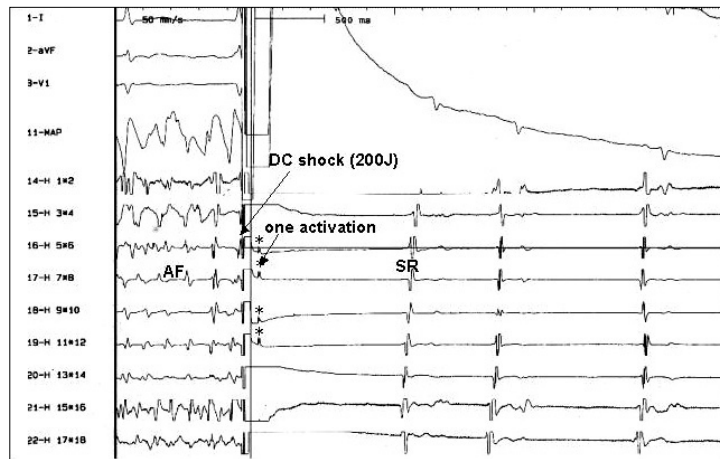
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## 대상 및 방법

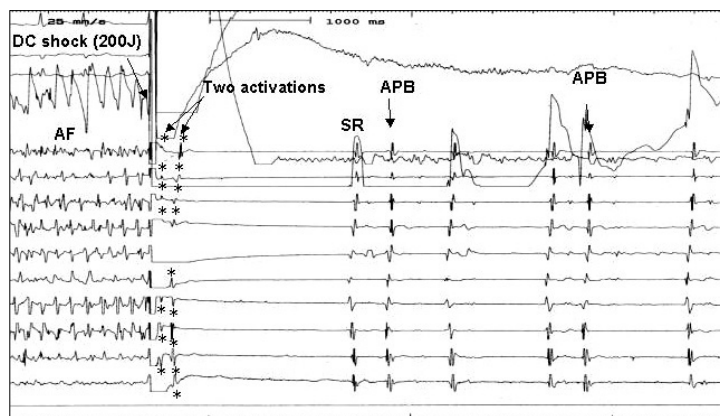
24  
2  
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23 20  
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warfarin (INR 2-3)  
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heparin(5000 unit)  
Seldinger  
20 - pole (Duo - Deca, DAIG)  
, Pentothal so -  
dium(3-5 mg/kg) (eyelid reflex)  
가  
R 100 J  
200 J, 300 J 360 J  
5 (Fig. 1)  
260 J  
가  
가 가  
가 가 14 가  
가 4 (Fig. 2, 3).  
250 J, 225 J 가  
4  
가 10 (Fig. 4)  
(4, Fig. 5)  
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(5, Fig. 6).  
3 가  
(Fig. 7).  
196 J, 240 J, 264 J 340 J  
가  
(Fig. 8,  $p = 0.44$ ).



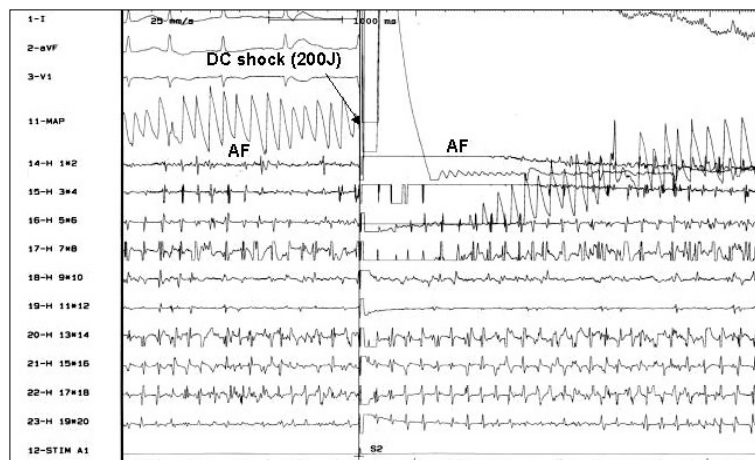
**Fig. 1.** Activation pattern following successful DC cardioversion : immediate resumption of normal sinus rhythm (n=5). AF : atrial fibrillation, DC : direct current, SR : sinus rhythm.



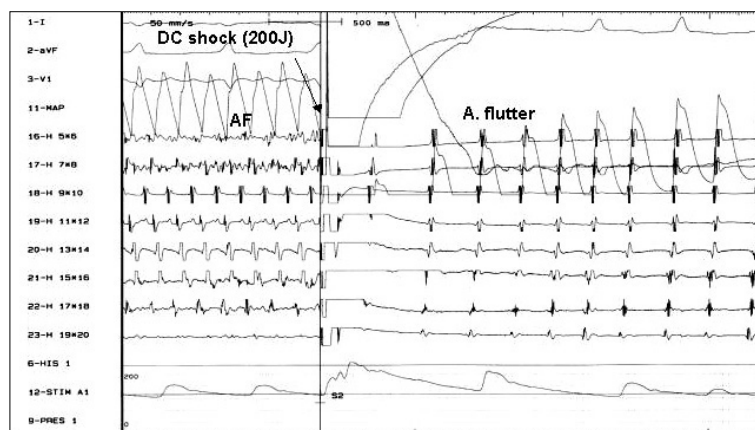
**Fig. 2.** Activation pattern following successful DC cardioversion : one activation (marked by\*) immediately after shock preceded normal sinus rhythm (n=13). AF : atrial fibrillation, DC : direct current, SR : sinus rhythm.



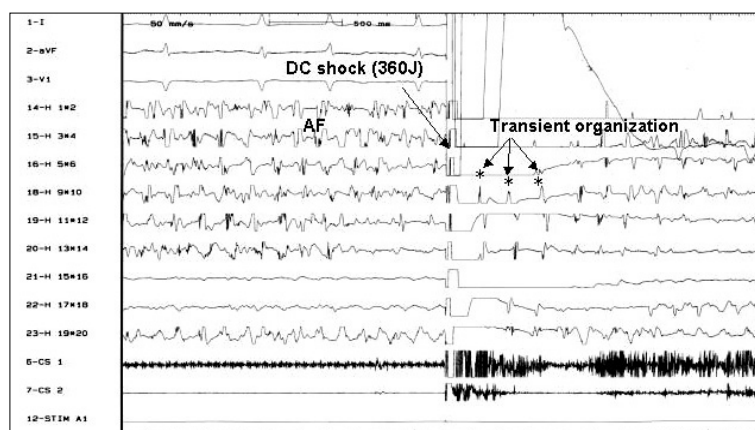
**Fig. 3.** Activation pattern following successful DC cardioversion : two activations (marked by\*) immediately after shock preceded normal sinus rhythm (n=4). DC : direct current, AF : atrial fibrillation, APB : atrial premature beat, SR : sinus rhythm.



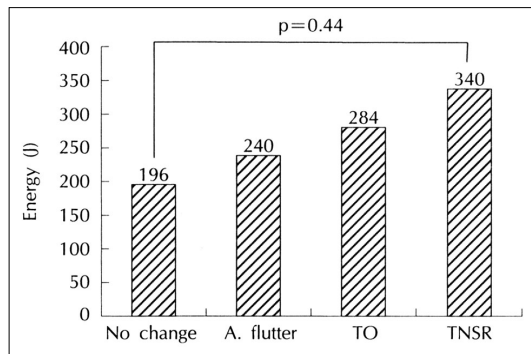
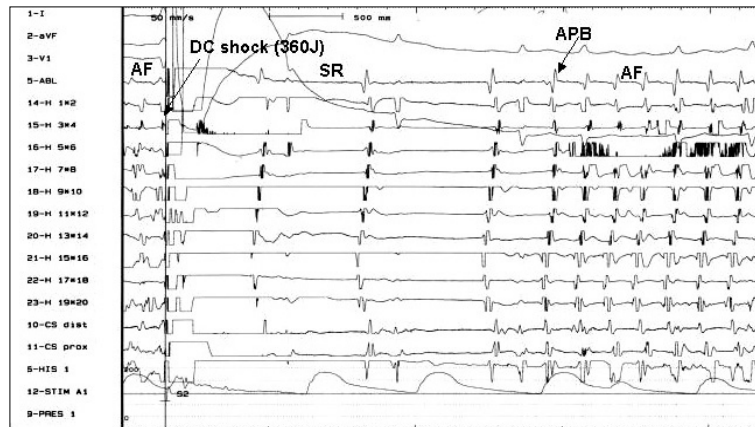
**Fig. 4.** Activation pattern following unsuccessful DC cardioversion : there was no significant changes in activation pattern between before and after DC shock (n=10). DC : direct current, AF : atrial fibrillation.



**Fig. 5.** Activation pattern following unsuccessful DC cardioversion : conversion to atrial flutter (n=4). DC : direct current, AF : atrial fibrillation, A. flutter : atrial flutter.



**Fig. 6.** Activation pattern following unsuccessful DC cardioversion : transient organization (marked by\*) wave noted before reverted to AF (n=5). DC : direct current, AF : atrial fibrillation.



가  
가 .  
가  
가  
가 ? (cardiac fib -  
rillation) “ multiple wavelet ” “ critical mass ”가  
가 .  
“ multiple wavelet ”가  
3 6

## 고 찰

전기 충격 후 성공적인 울동 전환시 관찰된 전기 활동 양상

7)8)

가

multiple wavelet 가

.

“critical mass ” 가

가

9)10)

critical

가

critical mass

activation)

11)

가

(postshock isoelectric window)

triggered activity

가

13%,<sup>21)</sup> 31%<sup>22)</sup>

(vulne -

가

22)23)

12)13)

가

ULV                    가

sotalol

ULV

21)22)

enone(2 mg/kg)

•

• ,

•

가

가

가

가 23

가

가 45

가

가

.

가

(internal cardioversion)

가 16) ,

가

mapping system

가

요 약

중심 단어 :

21

배경 및 목적 :

방 법 :  
(n=20) (n=3)  
20 - pole (Duo - Deca, DAIG)  
(n=22) (n=23)  
100 360 J  
결 과 :  
가 5 (21%)  
2 2  
가 1  
(n=14) 2 (n=4) 가  
가 18 (79%)  
(n=22)  
가 (n=10)  
(n=4),  
가  
(n=5)  
(n=3)가  
196 J, 240 J, 264 J 340 J  
가

결 론 :

## REFERENCES

- 1) Ewy GA, Horan WJ. *Effectiveness of direct current defibrillation: role of paddle electrode size. Am Heart J* 1977; 93:674-5.
- 2) Connell PN, Ewy GA, Dahl CF, Ewy MD. *Trans thoracic impedance to defibrillator discharge; effect of electrode size and electrode-chest wall interface. J Electrophysiol* 1973;6:313-7.
- 3) Bjerkelund C, Orning OM. *An evaluation of DC shock treatment of atrial arrhythmias. Acta Med Scand* 1968; 184:481-91.
- 4) van Gelder IC, Crijns HJ, van Gilst WH, Verwer R, Lie KI. *Prediction of uneventful cardioversion and maintenance of sinus rhythm from direct-current electrical cardioversion of chronic atrial fibrillation and flutter. Am J Cardiol* 1991;68:41-6.
- 5) van Gelder IC, Crijns HJGM, Hillege H, Lie KI. *Value and limitations of DC electrical cardioversion of chronic atrial fibrillation. Pacing Clin Electrophysiol* 1995;18 (II):798.
- 6) Levy S, Lauribe P, Dolla E, Kou W, Kadish A, Calkins H, Pagannelli F, Moyal C, Bremond M, Schork A. *A randomized comparison of external and internal cardioversion of chronic atrial fibrillation. Circulation* 1992;86: 1415-20.
- 7) Moe GK. *On the multiple wavelet hypothesis of atrial fibrillation. Arch Int Pharmacodyn Ther* 1962;140:183-8.
- 8) Allesie MA, Lammers WJ, Bonke FI. *Experimental evaluation of Moe's multiple wavelet hypothesis of atrial fibrillation. In: Zipes DP, Jalife J, editors. Cardiac Electrophysiology and Arrhythmias. New York: Grune & Stratton; 1985. p.265-75.*
- 9) Garrey WE. *The nature of fibrillation contraction of the heart: its relation to tissue mass and form. Am J Physiol* 1914;33:397-414.
- 10) Kim YH, Garfinkel A, Ikeda T, Wu TJ, Athill CA, Weiss JN, Karagueuzian HS, Chen PS. *Spatiotemporal complexity of ventricular fibrillation revealed by tissue mass reduction in isolated swine right ventricle: further evidence for the quasiperiodic route to chaos hypothesis. J Clin Invest* 1997;100:2486-500.
- 11) Zipes DP, Fischer J, King RM, Nicoll A deB, Jolly WW. *Termination of ventricular fibrillation in dogs by depolarizing a critical amount of myocardium. Am J Cardiol* 1975;36:37-44.

- 12) King BG. *The effect of electric shock on heart action with special reference to varying susceptibility in different parts of the cardiac cycle (thesis)*. New York: Columbia University; 1934.
- 13) Orias O, Gilbert JL, Siebens AA, Suckling EE, Brooks CM. Effectiveness of single rectangular electrical pulses of known duration and strength in evoking auricular fibrillation. *Am J Physiol* 1950;162:219-25.
- 14) Chen PS, Shibata N, Dixon EG, Martin RO, Ideker RE. Comparison of defibrillation threshold and the upper limit of ventricular vulnerability. *Circulation* 1986;73:1022-8.
- 15) Lesigne C, Levy B, Saumont R, Birkui P, Bardou A, Rubin B. An energy-time analysis of ventricular fibrillation and defibrillation thresholds with internal electrodes. *Med Biol Eng* 1976;14:617-22.
- 16) Chen P-S, Wolf PD, Melnick SD, Danieleley ND, Smith WM, Ideker RE. Comparison of activation during ventricular fibrillation and following unsuccessful defibrillation shocks in open-chest dogs. *Circ Res* 1990;66:1544-60.
- 17) Frazier DW, Wolf PD, Wharton JM, Tang AS, Smith WM, Ideker RE. Stimulus induced critical point: mechanism for electrical initiation of reentry in normal canine myocardium. *J Clin Invest* 1989;83:1039-52.
- 18) Han J. Ventricular vulnerability to fibrillation. In: Dreifus LS, Likoff W, editors. *Cardiac Arrhythmias*. New York: Grune & Stratton, Inc.; 1973. p.87-95.
- 19) Chen PS, Wolf PD, Dixon EG, Danieleley ND, Frazier DW, Smith WM, Ideker RE. Mechanism of ventricular vulnerability to single premature stimuli in open-chest dogs. *Circ Res* 1988;62:1191-209.
- 20) Kuo CS, Munakata K, Reddy CP, Surawicz CB. Characteristics and possible mechanism of ventricular arrhythmia dependent on the dispersion of action potential durations. *Circulation* 1983;67:1356-67.
- 21) Timmermans C, Rodriguez LM, Smeets JL, Wellens HJ. Immediate reinitiation of atrial fibrillation following internal atrial defibrillation. *J Cardiovasc Electrophysiol* 1998;9:122-8.
- 22) Tse HF, Lau CP, Ayers GM. Incidence and modes of onset of early reinitiation of atrial fibrillation after successful internal cardioversion, and its prevention by intravenous sotalol. *Heart* 1999;82:319-24.
- 23) Chen SA, Hsieh MH, Tai CT, Tsai CF, Prakash VS, Yu WC, Hsu TL, Ding YA, Chang MS. Initiation of atrial fibrillation by ectopic beats originating from the pulmonary veins: electro-physiological characteristics, pharmacological responses, and effects of radiofrequency ablation. *Circulation* 1999;100:1879-86.
- 24) Haissaguerre M, Jais P, Shah DC, Takahashi A, Hocini M, Quiniou G, Garrigue S, Le Mouroux A, Le Metayer P, Clementy J. Spontaneous initiation of atrial fibrillation by ectopic beats originating in the pulmonary veins. *N Engl J Med* 1998;339:659-66.