Acta Medica et Biologica
Vol. 40, No. 1, 35-41, 1992

The Use of Isoproterenol in Electrophysiologic Drug Testing in Patients with Sustained Ventricular Tachycardia: The Mechanism and Clinical Significance of Isoproterenol

Masahito SATOH

Department of Internal Medicine I, Niigata University School of Medicine, Asahimachi 1, Niigata, 951 Japan

Received January 14, 1992

Summary. **Isoproterenol has been used in electrophysiologic studies to facilitate the induction of ventricular tachycardia (VT) as well as in drug testing. However, the mechanism of the induction of VT and the clinical significance of the VT induced with isoproterenol have yet to be determined. The present study assessed the effects of isoproterenol in the induction of VT during drug testing in 23 patients (34 drug testings), and analyzed the patients' characteristics and electrophysiologic parameters. The standard protocol for inducing VT was used.**

Sustained monomorphic VT was induced in 15 testings after the use of isoproterenol (ineffective drug testing). In the other 19 testings, sustained VT was not induced even after the use of isoproterenol (effective drug testing).

Isoproterenol altered the electrophysiologic parameters in a similar manner in the two testings. However, nonsustained VT was more frequently induced before isoproterenol in the ineffective drug testings: 60% vs 16% ($P<0.05$). This indicates that isoproterenol converted nonsustained VT into sustained VT, implying that isoproterenol improved the conduction within the slow conduction zone, resulting in VT which did not terminate spontaneously. Facilitated conduction outside the reentry circuit, namely, the interventing tissue between the stimulation site and the reentry circuit, likely played a minor role. The majority of patients treated with an effective drug showed no recurrence of VT during the follow-up period.

INTRODUCTION

Most sustained ventricular tachycardia (VT) can be induced by programmed electrical stimulations, and therapy guided by electrophysiologic study has come to be considered essential.[1-3] However, some VTs can be induced by programmed electrical stimulation only after the use of isoproterenol. This induced VT has the same QRS morphology as clinically documented VT.[1-3] Though a general guideline has been presented concerning the method of the induction of VT,[4] the significance of isoproterenol in drug testing has not been fully established.[3,5] This paper reports on the role of isoproterenol in drug testing by analyzing the incidence of the induction of sustained VT, and the conversion of nonsustained VT to sustained VT after the use of isoproterenol. Follow-up data are also presented.

PATIENTS AND METHODS

Patients: Seventy-five patients with documented symptomatic sustained VT and sustained VT induced in a drug-free state underwent serial drug testing to select effective antiarrhythmic agents. Twenty-three of the patients received isoproterenol in 34 drug testings, as the efficacy of antiarrhythmic agents was judged only after the completion of the whole VT induction protocol which included the use of isoproterenol. The clinical characteristics of these 23 patients are presented in Table 1. Twenty-two were male and one was female, with ages ranging from 13 to 70 with a mean age of 59 years. Thirteen patients (56%) had had a history of syncope. The cycle length of clinically documented sustained VT was 298 ± 41 msec. A 12 lead electrocardiogram (ECG) of the sustained VT was available for 20 patients.

Electrophysiologic study: The electrophysiologic study was performed in a postabsorptive and nonsedated state after informed consent had been obtained. Quadripolar catheters (USCI 6F multipur-

Table 1. Clinical Profiles of Patients (N=23)

Male : Female	22 : 1
Age (y.o.)	13-70 (mean 59)
Primary heart disease	
Prior MI	7
Non-ischemic LVA	4
Cardiomyopathy	4
ARVD	7
T/F post op	1
History of syncope	13/23 (57%)
Cycle length of VT	298±41 msec

MI=Myocardial infarction, LVA=Left ventricular aneurysm ARVD=Arrhythmogenic right ventricular dysplasia
T/F post op=Post operative state of Tetralogy of Fallot
Cycle length of VT=Cycle length of documented sustained VT

pose catheter, Bellirica, MA) were introduced into the right femoral vein, and placed against the right ventricular apex, the outflow tract, and the recording site for his bundle potential. Another quadripolar catheter was placed within the left ventricle, and used for recording and stimulation.

Ventricular stimulations were performed using a programmable stimulator (Fukuda Denshi Co., Cardiac stimulator BCO2) that delivered rectangular pulses 2 msec in width at twice the diastolic threshold. The standard protocol was employed for the induction of VT. After 8 basic drives at two cycle lengths (600 msec and 400 msec), one to two premature stimuli were delivered. An incremental ventricular burst pacing up to 210 beats per minute was then added for 5 to 10 sec. The ventricular pacing was performed from the right ventricular apex and the outflow tract. If sustained VT was not induced, isoproterenol was infused intravenously. Stimulation was finally given from the left ventricle. Surface ECG leads I, II and V1 were recorded simultaneously with intracavitary electrograms at a paper speed of 100 mm/sec (Siemens-Elema Mingograf 82, Solna, Sweden).

Drug testing: After confirmation that sustained VT could be induced in the control state, serial drug testing started. When antiarrhythmic drugs prevented the induction of sustained VT before the use of isoproterenol, isoproterenol was infused to increase the sinus rate by 20%,[1-3] and the programmed electrical stimulations were repeated. If sustained VT was not able to be induced from two sites in the right ventricle, we attempted the stimulation from the left ventricle. If sustained VT was induced before isoproterenol administration, the induction study was ended before the use of isoproterenol.

Antiarrhythmic drugs: First, procainamide was given intravenously at doses of between 600 mg to 1,000 mg in 6 to 10 min, or orally at doses of between 2,500 mg and 3,000 mg daily for more than 3 days. When procainamide failed to suppress the induction of sustained VT, another drug was tested. The antiarrhythmic agents and their doses used in the present study are summarized in Table 2.

Definitions: 1) Sustained VT was defined as VT lasting more than 15 complex beats, or requiring immediate termination because of hemodynamic deterioration according to earlier workers.[6,7] 2) Nonsustained VT was defined as VT that lasted from 6 to 14 complex beats. 3) Effective drug testing: An antiarrhythmic drug was considered effective if it prevented the induction of VT lasting more than 15 complex beats even if the whole protocol of induction was completed.[6] 4) Ineffective drug testing: A drug was considered ineffective if VT lasting more than 15 complex beats was induced.[6]

Data analysis: From the results of the drug testings, patients were classified into three groups: one with sustained VT induced before isoproterenol, one with VT induced only after isoproterenol, and one with no sustained VT able to be induced even after isoproterenol. In the present study, we focused on the latter

Table 2. Summary of Drugs Used

Drug regimen	No.	Drug doses
Procainamide	12	600 mg-1000 mg I.V. 2500 mg-3000mg/day P.O.
Disopyramide	6	100 mg I.V. 400 mg-600 mg/day P.O.
Aprindine	2	80 mg/day P.O.
Propafenon	2	450 mg/day P.O.
Flecainide	3	200-300 mg/day P.O.
Mexiletine	1	400 mg/day P.O.
Amiodarone	5	400 mg/day P.O. for 7 days, then 200 mg/day P.O. for 7 days
Combination	3	
(Disopyramide+Mexiletine=2)		
(Disopyramide+Procainamide=1)		

No.=Number of studies, I.V.=Intravenously
P.O.=Orally.

two groups, and analyzed their clinical characteristics, the effects of isoproterenol on the electrophysiologic parameters, and their clinical courses.

Statistical analysis: Data were expressed as means±standard deviations, and statistically analyzed with Student's t-test for paired or unpaired comparisons, and a qui-square test. A p-value of less than 0.05 was considered significant.

RESULTS

Induction of nonsustained VT before isoproterenol (Table 3): As a determination of patient selection, sustained VT was not induced before the administration of isoproterenol in 23 patients. Nonsustained VT was induced in 12 drug testings, but not in the other 22 drug testings. The QRS morphology of the induced nonsustained VT was identical to that of clinically documented VT in 5 drug testings, and in 4 drug testings the VTs showed a different QRS morphology. The 12 lead ECG of the documented sustained VT was not available for the remaining 3 patients with nonsustained VT. The mean cycle length of induced nonsustained VT was 366±81 msec.

Isoproterenol and the induction of sustained VT (Table 3): Isoproterenol was administered in 34 drug testings. The sinus cycle length was shortened from 936±153 msec to 760±123 msec (decreased by 18.8%), and the effective refractory period of the right ventricle decreased from 241±21 msec to 226±17 msec (decreased by 6.6%).

Sustained VT was induced in 15 (44%) of 34 drug testings in 13 patients. The 15 induced sustained VTs were monomorphic, and ventricular fibrillation or polymorphous VT was not induced. The mean cycle length of the 15 induced sustained VTs was 322±55 msec. The QRS morphology of 10 of the induced sustained VTs was identical to that of clinical VT, and 2 VTs showed a different QRS morphology. The 12 lead ECG of clinically documented VT was not available for 3 patients. Sustained VT was not induced in the remaining 19 (56%) drug testings among 15 patients even after isoproterenol administration.

Sustained VT was induced with a single premature stimulus in 4 drug testings, and with double extra stimuli in 11 drug testings. The induction site was the right ventricle in 13 drug testings, and the left ventricle in 2 drug testings. In 13 sustained VTs induced from right ventricular pacing, 9 VTs were induced at a coupling interval longer than the effective refractory period determined before isoproterenol administration. The remaining 4 sustained VTs were induced at coupling intervals shorter than the effective refractory periods determined before receiving isoproterenol.

Conversion of nonsustained VT into sustained VT with isoproterenol (Table 4): Nine of the 12 nonsustained VTs induced before isoproterenol administra-

Table 3. Induced NSVT before ISP and SVT after ISP

	ISP (−)	ISP (+)
SCL	936±153 msec	760±123 msec
ERP	241±21 msec	226±17 msec
Induced NSVT	12/34 (35%)	
Clinical	5	
Nonclinical	4	
Undefined	3	
CL of NSVT	366±81 msec	
Induced SVT		15/34 (42%)
Clinical		10
Nonclinical		2
Undefined		3
CL of SVT		322±55 msec

ISP=Isoproterenol, NSVT=Induced nonsustained VT
SVT=Induced sustained VT
ISP (-)=Before isoproterenol administration
ISP (+)=After isoproterenol administration
SCL=Sinus cycle length, ERP=Effective refractory period
Clinical=Induced VT with QRS morphology identical to clinical VT
Nonclinical=Induced VT with QRS morphology different from clinical VT
Undefined=Induced VT in patients whose 12 lead ECGs were not available

Table 4. Conversion of NSVT into SVT

NSVT before ISP 12	—	No SVT after ISP	3
	—	SVT after ISP	9
		Identical QRS	6/9
		Different QRS	3/9

NSVT = Induced nonsustained VT, SVT = Induced sustained VT
ISP=Isoproterenol administration
Identical QRS=Induced sustained VT with QRS morphology identical to that of nonsustained VT before isoproterenol
Different QRS=Induced sustained VT with QRS morphology different from that of induced nonsustained VT before isoproterenol

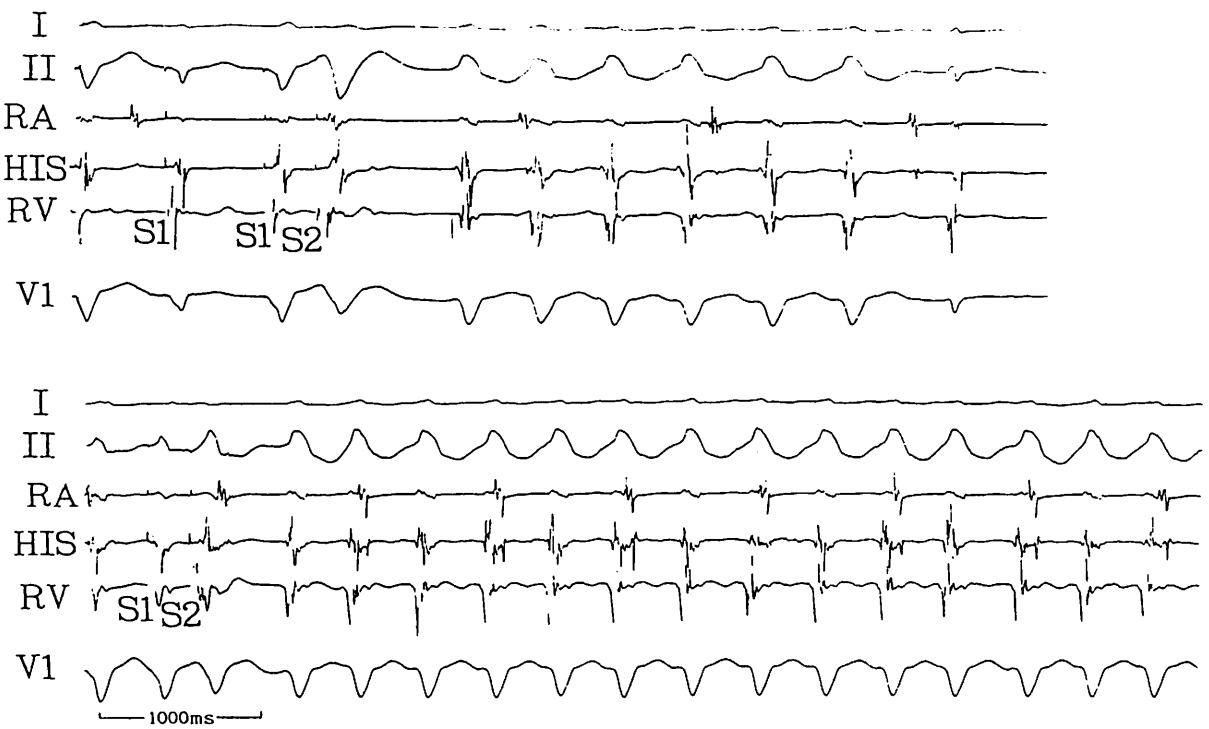

Fig. 1. The conversion of nonsustained VT into sustained VT. Nonsustained VT was induced by programmed electrical stimulations (S1 and S2) before isoproterenol administration (Upper). After isoproterenol, sustained VT with ECG morphology identical to that of nonsustained VT was induced (Lower). Surface ECG lead I, II and V1 with intracavitary electrograms from the right atrium (RA), the recording site of His bundle potential, and the right ventricle (RV) are shown.

Table 5. Clinical Profiles of Patients with or without Effective Drug

	Effective drug (−) (N=8)	Effective drug (+) (N=15)
Male : Female	8 : 0	14 : 4
Mean Age	54	61
Primary heart disease		
Prior MI	2	5
Non-ischemic LVA	2	2
Cardiomyopathy	0	4
ARVD	3	4
T/F post op	1	0
History of syncope	5/8(63%)	8/15(53%)
Cycle length of VT	316±58 msec	279±28 msec

Effective drug (−)=Patients with no effective drug
Effective drug (+)=Patients with one or more effective drugs
Cycle length of VT=Cycle length of documented sustained VT
MI=Myocardial infarction, LVA=Left ventricular aneurysm
ARVD=Arrhythmogenic right ventricular dysplasia
T/F post op=Post operative stste of Tetralogy of Fallot

Table 6. Electrophysiologic Features of Effective and Ineffective Drug Testings

	Effective (N=19)		Ineffective (N=15)	
	ISP (−)	ISP (+)	ISP (−)	ISP (+)
SCL	990±98	782±61	920±170	745±125
ERP	239±13	223±12	242±27	230±21
NSVT (%)	3 (16%)*		9 (60%)*	
(CL)	(340±22)		(371±84)	
SVT (%)		0 (0%)*		15 (100%)*
(CL)				(322±55)

Effective=Effective drug testing
Ineffective=Ineffective drug testing
ISP (−)=Before isoproterenol administration
ISP (+)=After isoproterenol administration
SCL=Sinus cycle length, ERP=Effective refractory period
CL=Cycle length of VT, NSVT=Induced nonsustained VT
SVT=Induced sustained VT, (*)=$P<0.05$

tion showed a conversion into sustained VT after receiving isoproterenol. Six of these 9 VTs showed identical QRS morphologies to those of VT induced after receiving isoproterenol; however, the mean cycle length of the 6 VTs decreased from 405±72 msec to 336±46 msec. A case of conversion of non-sustained VT into sustained VT after isoproterenol was showed in Fig. 1.

Comparison of characteristics between patients with and without effective drugs (Table 5): One or more effective drugs were confirmed in 15 patients but not in the other 8 patients. Clinical characteristics of age, the underlying heart disease, the incidence of syncopal episodes, and the cycle length of clinically documented VT did not differ between the 15 patients with effective antiarrhythmic drugs and the 8 patients with no effective drugs.

Comparison of electrophysiologic parameters between effective and ineffective drug testings (Table 6): The effects of isoproterenol on the sinus cycle length and the effective refractory period are summarized in Table 6. In ineffective drug testings, sinus cycle length was shortened from 920±170 msec to 745±125 msec with isoproterenol (decreased by 19.0%), and the effective refractory period was shortened from 242±27 msec to 230±21 msec (decreased by 5.0%). In effective drug testings, the sinus cycle length was shortened from 990±98 msec to 782±61 msec with isoproterenol (decreased by 21.0%), and the effective refractory period was shortened from 239±13 msec to 223±12 msec (decreased by 6.7%). The effects of isoproterenol on the sinus cycle length and the effective refractory period were not different between the two testings.

However, nonsustained VT was induced in 9 of the 15 ineffective drug testings before isoproterenol administration (60%), and the incidence was significantly greater than that in the effective drug testings; 16% ($P<0.05$).

Clinical follow up: Fifteen patients were treated with effective antiarrhythmic drugs. Four of the 8 patients in whom no effective drugs were found underwent other therapies such as surgery or electrical catheter ablation. However, the remaining 4 patients were treated with drugs which, though unable to prevent the induction of VT, were able to reduce its rate.

During a mean follow-up period of 21.7 months (3-45 months), sustained VT recurred in 3 of these 4 patients (75%) in whom no drugs had been effective. In contrast, 13 of the 15 patients (87%) treated with effective drugs were free of recurrence and all survived.

DISCUSSION

Evidence has been accumulating that the mechanism of most sustained VT is reentry, which includes the phenomena of transient entrainment,[8] abnormal local electrical activity,[8,9] and direct pacing of the slow conduction zone.[10]

Electrophysiologic studies have been established as essential in assessing drug efficacy, but their success rate in finding effective antiarrhythmic drugs is limited. The results of such testings are known to be profoundly affected by the induction protocol[11-14]; the number of the extra stimuli, the site of the stimulation, and the cycle length of the basic stimulations.[11] At times the induction of VT is achieved by the use of isoproterenol, and the antiarrhythmic effect of a drug in preventing the induction of VT can also be reversed with isoproterenol.[13,14] Therefore, isoproterenol was employed to confirm drug efficacy.

In our previous study[15] it was found that if VT was able to be induced after pharmacological or nonpharmacological intervention, VT almost always recurred and most of the patients died suddenly. The only exception was idiopathic VT, which was characterized by having an ECG morphology of the right bundle branch block and left axis deviation, and by its responsiveness to verapamil.[16] Until now, we have been using the induction protocol mentioned above, and testing the efficacy of antiarrhythmic drug therapy, or non-pharmacological intervention by such a protocol. Drugs were considered effective if sustained VT was not able to be induced even after the completion of the whole protocol. Actually, VT was induced in 15 (44%) of 34 drug testings after administering isoproterenol, and antiarrhythmic drugs were finally judged to be ineffective in the present study.

All sustained VTs induced after isoproterenol were monomorphic, and frequently the induced sustained VT had a QRS morphology identical to that of clinically documented VT. The clinical significance of monomorphic sustained VT has been well confirmed.[11,12]

We did not employ triple extra stimuli for the induction of VT before isoproterenol administration. Sustained VT might be induced more frequently with a more aggressive stimulation protocol such as triple extra-stimuli. However, the significance of the use of triple extra-stimuli in VT with a non-ischemic cause has not been determined.

The mechanism of the facilitation of the induction of sustained VT with isoproterenol has not been fully

elucidated.[1-3,13-14] The clinical characteristics of the 8 patients for whom no effective drugs were found were not different from those in the other 15 patients for whom one or more drugs were effective (Table 5). The effects of isoproterenol on the effective refractory period, or sinus cycle length were the same in the effective and ineffective drug testings (Table 6).

Furthermore, when sustained VT was induced after using isoproterenol, the VT-initiating coupling interval was longer than the effective refractory period determined at the same stimulation site before its administration. The shortening of the effective refractory period at the stimulating site, or the intervening tissue between the stimulation site and the reentry circuit might be not important for the induction of VT with the use of isoproterenol. However, in 4 drug testings, VT was induced at a shorter coupling interval than the refractory period of the stimulation site which was determined before using isoproterenol. The stimulated wave fronts were able to reach the reentry circuit at shorter coupling intervals after isoproterenol, and a reentry circuit was established. In such instances, the shortening of the refractory period might be important in the induction of VT with isoproterenol.

When sustained VT was induced after isoproterenol administration, nonsustained VT had already been frequently induced before this. This means that VT was induced by the programmed stimulation before isoproterenol, but that it terminated spontaneously because of a block within the slow conduction zone.[17] If isoproterenol improves the conduction within the slow conduction zone, nonsustained VT would be converted into sustained VT. A preferential action of isoproterenol on the diseased myocardium was confirmed in an experimental study.[18,19] Conversion of nonsustained VT into sustained VT is the mechanism of facilitation in inducing VT with isoproterenol.

The use of a beta-blocker might be considered in the treatment of VTs induced after isoproterenol.[20,21] However, the preferable effect of beta-blockers was confirmed after further electrophysiologic study.[20-23] Patients in whom no drugs are effective should be treated by nonpharmacological therapies, such as surgery or catheter electrical ablations as sustained VT may be cured permanently.[22] Drug testing using electrophysiologic studies including isoproterenol administration would be useful to predict the clinical courses of patients with sustained VT.

CONCLUSION

The efficacy of drugs in treating sustained VT was evaluated by testing guided by electrophysiologic study which included the use of isoproterenol for the induction of VT. The clinical characteristics and the responses of electrophysiologic parameters to isoproterenol did not differ between the testings in which sustained VT was not induced after isoproterenol—the effective drug testings—and the testings in which sustained VT was induced after isoproterenol—the ineffective drug testings. However, nonsustained VT was frequently induced before isoproterenol administration in the ineffective drug testings.

The present study suggests that the mechanism of the induction of sustained VT with isoproterenol is the conversion of nonsustained VT into sustained VT. Improved conduction within the slow conduction zone would be responsible for a such conversion. As to the clinical significance of this in the treatment of VT, those patients in whom induction of VT was prevented even after isoproterenol administration showed a lower rate of recurrence of their VT and no deaths during the follow-up period.

Acknowledgments. The author expresses his appreciation to Prof. Akira Shibata, and Dr. Yoshifusa Aizawa, for their constructive advice on this manuscript.

REFERENCES

1) Olshansky B, Martins JB: Usefulness of isoproterenol facilitation of ventricular tachycardia induction during extrastimulus testing in predicting effective chronic therapy with beta-adrenergic blockade. *Amer J Cardiol* 59: 573-577, 1987.
2) Reddy P, Gettes LS: Use of isoproterenol as an aid to electric induction of chronic recurrent ventricular tachycardia. *Amer J Cardiol* 44: 705-712, 1979.
3) Freedman RA, Swerdlow CD, Echt DS, Winkle RA Soderholm-Difatte V, Mason JW: Facilitation of ventricular tachycardia induction by isoproterenol. *Amer J Cardiol* 54: 765-770, 1984.
4) Zipes DP: Guideline for clinical intracardiac electrophysiologic studies. A report of the American college of cardiology/American heart association. Task force on assessment of diagnostic and therapeutic cardiovascular procedures (Subcommittee to assess clinical intracardiac electrophysiologic study). *J Amer Coll Cardiol* 14: 1827-1742, 1989.
5) Mason JW, Winkle RA: Accuracy of the ventricular tachycardia-induction study for predicting long-term

efficacy and inefficacy of antiarrhythmic drugs. *New Eng J Med* 303: 1073-1077, 1980.
6) Rae AP, Greenspan AM, Spielman SR, Sokoloff NM, Webb CR, Kay HR, Horowitz LN: Antiarrhythmic drug efficacy for ventricular tachyarrhythmias associated with coronary artery disease as assessed by electrophysiologic studies. *Amer J Cardiol* 55: 1494-1499, 1985.
7) Waller T, Kay H, Spielman SR, Kutalek SP, Greenspan AM, Horowitz LN: Reduction in sudden death and total mortality by antiarrhythmic therapy evaluated by electrophysiologic drug testing: Criteria of efficacy in patients with sustained ventricular tachyarrhythmia. *J Amer Coll Cardiol* 10: 83-89, 1987.
8) Aizawa Y, Oda H, Satoh M, Murata S, Shibata A, Eguchi S: Transient entrainment of ventricular tachycardia with continuous local electrical activity. *Amer Heart J* 114: 182-184, 1987.
9) Fitzgerald DM, Friday KJ, Yeung Lai Wah JA, Lazzara R, Jackman WM: Electrogram patterns predicting successful catheter ablation of ventricular tachycardia. *Circulation* 77: 806-814, 1988.
10) Stevenson WG, Nademanee K, Weiss JN, Baron K, Yeatman LA, Sherman T: Programmed electrical stimulation at potential ventricular reentry circuit sites-Comparison of observations in humans with predictions from computer stimulations. *Circulation* 80: 793-806, 1989.
11) Brugada P, Green M, Abdollah H, Wellens HJJ: Significance of ventricular arrhythmia initiated by programmed ventricular stimulation: the importance of the type of ventricular arrhythmia induced and the number of premature stimuli required. *Circulation* 69: 87-92, 1984.
12) Baerman JM, Morady F, Buitleir M, Dicarlo LA, Kou WH, Nelson SD: Prospective comparison of programmed ventricular stimulation with triple extrastimuli versus single and double extrastimuli during infusion of isoproterenol. *Amer Heart J* 117: 342-347, 1989.
13) Morady F, Kou WH, Kadish AH, Nelson SD, Toivonen LK, Kushner JA, Schmaltz S, BuitleirM: Antagonism of Quinidine's electrophysiologic effects by epinephrine in patients with ventricular tachycardia. *J Amer Coll Cardiol* 12: 388-394, 1988.
14) Jazayeri MR, Vanwhye G, Avitall B, Mckinnie J, Tchou P, Akhtar M: Isoproterenol reversal of antiarrhythmic effects in patientswith inducible sustained ventricular tachyarrhythmias. *J Amer Coll Cardiol* 14: 705-711, 1989.
15) Aizawa Y, Murata M, Satoh M, Funazaki T, Matsuoka A, Shibata A, Eguchi S: Requirements of nonpharmacological interventions in the treatment of recurrent sustained ventricular tachycardia. *Jap Circ J* 54: 1340-1348, 1990.
16) Lin FC, Finley D, Rahimtoola SH, Wu D: Idiopathic paroxysmal ventricular tachycardia with a QRS pattern of right bundle branch block and left axis deviation: aunique clinical entity with specific properties. *Amer J cardiol* 52: 95-100, 1983.
17) Aizawa Y, Ebe K, Satoh M, Shibata A: Conduction through the reentrant circuit in recurrent sustained ventricular tachycardia evaluated by use of transient entrainment. *Jap Circ J* 54: 1113-1121, 1990.
18) Gilmour RF, Heger JJ, Prystowsky EN, Zipes DP: Cellular electrophysiologic abnormalities of diseased human ventricular myocardium. *Amer J Cardiol* 51: 137-144, 1983.
19) Kay GN, Epstein AE, Plumb VJ: Preferential effect of procainamide on the reentrant circuit of ventricular tachycardia. *J Amer Coll Cardiol* 14: 382-390, 1989.
20) Munsif A, Saksena S: Efficacy of nadolol alone or in combination with a type A antiarrhythmic drug in sustained ventricular tachycardia: A prospective study. *PACE* 12: 1816-1826, 1989.
21) Kienzle MG, Martins JB, Wendt DJ, Constantin L, Hopson R, Mccue ML: Enhanced efficacy of oral sotalol for sustained ventricular tachycardia refractory to type 1 antiarrhythmic drugs. *Amer J Cardiol* 61: 1012-1017, 1988.
22) Niwano S, Aizawa Y, Satoh M, ShibataA: Low energy electrical catheter ablation of sustained ventricular tachcardia originating from the right ventricle. *Amer Heart J* 117: 1156-1157, 1989.
23) Kim SG, Seiden SW, Felder SD, Waspe LE, Fisher JD: Is programmed electrical stimulation of value in predicting the long term success of antiarrhythmic therapy for ventricular tachycardia? *New Eng J Med* 315: 356-62, 1986