Ventricular Tachycardia Ablation as First Line Therapy: Are We There Yet?

LUIGI DI BIASE, M.D., PH.D.,*,†,‡,§ PASQUALE SANTANGELI, M.D.,*,§,¶
J. DAVID BURKHARDT, M.D.,* and ANDREA NATALE, M.D.*,‡,¶

From the *Texas Cardiac Arrhythmia Institute, St. David's Medical Center, Austin, Texas, USA; †Albert Einstein College of Medicine at Montefiore Hospital, Bronx, New York, USA; ‡Department of Biomedical Engineering, University of Texas, Austin, Texas, USA; §Department of Cardiology, University of Foggia, Foggia, Italy; and ¶Division of Cardiology, Stanford University, Palo Alto, California, USA

catheter ablation, electrophysiology, implantable cardioverter-defibrillator, ventricular fibrillation, ventricular tachycardia

Editorial Comment

Coronary disease is the most common cause of sudden cardiac arrest in Western countries[1,2] and scar-related reentry is the most important mechanism leading to sustained ventricular tachycardia (VT).[3]

Several randomized trials have shown the efficacy of implantable cardioverter-defibrillators (ICD) in reducing mortality both in primary and secondary prevention in patients with coronary artery disease and high risk of sudden cardiac death.[4]

Approximately 20% of patients in primary prevention and 45% of patients in secondary prevention receive an appropriate ICD intervention within the 2 years following ICD implantation.[5-7]

In addition, VT storm, defined as 3 or more appropriate ICD therapies within a 24-hour period, may affect 4% and 20% of the patients in the primary and secondary prevention, respectively.[8,9]

However, ICD shocks decrease quality of life, increase patient's anxiety and increase the risk of nonarrhythmic mortality.[5,10-12]

The therapeutic options to reduce ICD shocks and increase survival rates are represented by antiarrhythmic drugs (AADs) and VT catheter ablation.

AADs have shown unsatisfactory results on survival and little effects on ICD shocks reduction.[2,13-15]

Radiofrequency catheter ablation for the treatment of drug-refractory recurrent VT in patients with ischemic cardiomyopathy has shown satisfactory results[8,16-26] especially in the setting of VT storm.[3,26,27]

Over the years, advances in technologies and techniques for VT ablation, such as the use of open irrigated catheters,[26] 3D mapping systems,[3] and the use of percutaneous epicardial ablation[28,29] have expanded the referrals to VT ablation and improved procedural outcomes. The majority of data on VT ablation in the setting of coronary artery disease are restricted to patients experiencing VT refractory to AADs (secondary VT ablation).[3,15,19,24,26,30]

As of today, only 3 studies have evaluated the role of catheter ablation as first line therapy.[17,18,20] The VTACH study[17] is the only available study that enrolled patients who were implanted with a primary prevention indication and had a subsequent appropriate ICD therapy for sustained hemodynamically stable VT. Each of these studies is exposed to different criticisms.

Schreieck *et al.*[20] in a small (39 pts) pilot study randomized patients undergoing secondary prevention ICD implantation for postinfarct sustained VT to early VT ablation with ICD implantation (19 pts) versus ICD alone. After a relatively short follow-up, no statistically significant difference in regards to VT recurrence was shown (47% recurrence in the ablation arm and 60% in the ICD arm). The study (published in an abstract format only) does not allow us to draw any conclusion because important information were lacking or not provided. The full manuscript once published might clarify several lacking points.

The Substrate Mapping and Ablation in Sinus Rhythm to Halt Ventricular Tachycardia trial (SMASH-VT) was a multicenter prospective, unblinded, randomized trial that sought to determine whether early catheter ablation of VT could reduce the recurrence of sustained VT in patients undergoing ICD implantation for secondary prevention.[18] The authors claimed to perform "prophylactic VT catheter ablation," although enrolled patients had already experienced an episode of life-threatening sustained VT. The study initially enrolled patients undergoing secondary prevention ICD implantation without distinction of the VAs responsible for the implantation (which could include ventricular fibrillation, unstable VT and syncope with inducible VT at EP study). Subsequently, patients undergoing ICD implantation for primary prevention and/or with an appropriate ICD intervention were enrolled. It is fair to say that the outcome of patients with VF is different from the one with spontaneous VT. Of note, patients were excluded if they were being treated with antiarrhythmic drugs (class I or class III), and if they were experiencing VT storm. Patients were randomized in a 1:1 fashion to catheter ablation or medical therapy without AADs. The primary study endpoint was freedom from appropriate ICD therapy whereas overall mortality and VT storm represented

J Cardiovasc Electrophysiol, Vol. 24, pp. 530-533, May 2013.

L. Di Biase serves as a consultant/advisory board member of Biosense Webster, Hansen Medical, St. Jude Medical, and Pfizer. A. Natale reports honoraria relevant to this topic from Boston Scientific, Medtronic, Biotronik, St. Jude Medical, and Biosense Webster; he serves as a consultant/advisory board member of Biosense Webster, Biotronik, St. Jude Medical, and Boston Scientific. Other authors: No disclosures.

Address for correspondence: Luigi Di Biase, M.D., Ph.D., 1015 East 32nd St., Suite 408, St. David's Medical Center, Austin, TX 78702, USA. E-mail: dibbia@gmail.com

doi: 10.1111/jce.12107

the secondary endpoints. A very important limitation in the study is the lack of data on ICD programming that could influence the outcome among the groups.

A total of 64 patients per group were enrolled without any significant baseline clinical characteristics but left ventricular ejection fraction ≤20% that was more common in the ablation group (25% vs 11%, P = 0.06). After 2-year follow-up a significant reduction of ICD shock was shown in the ablation group (9% vs 31%, HR = 0.27, 95% CI 0.11 to 0.67, P = 0.003). The number of patients that needed to be treated with ablation (NNT) to avoid 1 appropriate ICD intervention was 5, resulting in a total of 200 appropriate ICD interventions prevented every 1,000 patients treated with catheter ablation.

The absence of a control group with AADs such as amiodarone limits the relevance of the study and the benefit of the ablation treatment. Although a reduction in mortality was reported in the ablation group, the study was not powered to address this issue. The Cox proportional hazard model showed that the number of VTs induced at the EP study was the only variable associated with appropriate ICD intervention at follow-up, whereas inducibility after ablation did not influence the long-term clinical success.[31]

The VTACH trial (Multicenter Catheter Ablation of Stable Ventricular Tachycardia Before Defibrillator Implantation in Patients With Coronary Artery Disease) was a prospective, unblinded, randomized controlled trial (utilizing an intention to treat analysis) testing the hypothesis that early intervention with catheter ablation in patients with previous myocardial infarction, reduced left ventricular ejection fraction (i.e., ≤50%), and documented first episode of hemodynamically tolerated sustained VT undergoing secondary prevention ICD implantation would reduce the rate of recurrent VT or ventricular fibrillation compared with standard medical therapy plus ICD implantation.[17]

In this study differently from SMASH VT,[18] AADs use was allowed, although only 35% of patients in both groups were treated with amiodarone at baseline and no data were reported on the use of antiarrhythmic drugs at follow-up. Patients with VT storm were excluded also from this trial. The primary endpoint was the time from ICD implantation to recurrence of any sustained VT or ventricular fibrillation; the rates of total mortality, syncope, hospitalization for cardiovascular causes, VT storm, and number of appropriate ICD intervention at follow-up were among the secondary endpoints analyzed.

Importantly, in this trial detailed information on ICD programming modes were reported.

After a mean follow-up of 22.5 ± 9 months, the 52 patients allocated to ablation had significantly longer time to arrhythmia recurrence compared with the 57 assigned to the ICD only arm (median 18.6 months vs 5.9 months), and lower 2-year arrhythmia recurrence rates (53% vs 71%, HR = 0.61, 95% CI 0.37 to 0.99, P = 0.045). In this study, the NNT to prevent 1 episode of recurrent ventricular arrhythmia was 6, which accounted for a total of 180 malignant ventricular arrhythmias prevented every 1,000 patients treated. The use of AADs at follow up was underreported, thus affecting the quality of the results.

Interestingly, the overall mortality was not different between groups (8.5% vs 8.6%, P = 0.68) and especially in the ICD-only group mortality was extremely low when compared with AVID (Antiarrhythmics vs Implantable Defibrillators trial), where it was18.4%.[7]

This study as well as the others was not powered to address differences in mortality. Due to ethical issues and to the fact that ventricular arrhythmia recurrence at 2 years was present in more than half of the patients undergoing ablation in the VTACH study, the use of ablation as a stand-alone procedure cannot be recommended and ICD should be implanted in these patients.

In this issue of the *Journal*, Delacretaz *et al*.[32] analyzed the data of the VTACH STUDY not utilizing the intention to treat analysis but the actual on-treatment analysis. The difference in time to the first occurrence of VT or VF between treatments groups was more pronounced reaching a mean of 19.5 months in the ablation group. In addition, the relative risk for VT or VF was reduced by 49% (39% in the intention-to-treat analysis). Moreover, when utilizing the on-treatment analysis, VT ablation further reduced the number of appropriate interventions per patient and year. Freedom from VT and VF after 24 months follow-up increased from 29.2% to 48.3% with VT ablation in this study.

Although the authors should be congratulated for the additive information given to the readers by this analysis, it is still important to say that the recurrence rate in the ablation group was still high and not completely satisfactory to propose VT ablation as first line therapy.

Can the ablation technique modify the above-mentioned considerations?

In the VTACH study,[17] although ablation was guided by a combination of substrate mapping, activation mapping, entrainment mapping, and pace mapping, the ablation target was only the clinical monomorphic VT and no effort was taken against other VTs. The SMASH VT study accounts for the same limitation.[18] Both studies do not provide information on the type of VT recurrence experienced by the patients.

These studies report on a limited substrate ablation and especially in light of recent studies showing that a more extensive substrate ablation (LAVA,[33] HOMOGENEIZATION,[34] LATE POTENTIALS[35]) and more often than what previously believed epicardial VT ablation are associated with a very favorable outcome approaching around 85% freedom from any VT at 2 years follow-up and with a more limited use of AADs.[33-35]

Epicardial ablation was not utilized in any of the 3 previously described trials.[17,18,20]

In the SMASH-VT trial,[18] no correlation was found between persistence of VT inducibility after ablation and long-term outcome, but the predictive value of the number of induced VTs at the EP study in our opinion supports the rationale for an extensive substrate-based ablation approach targeting all the "abnormal potentials" within the scar. In the VTACH study,[17] all enrolled patients had history of hemodynamically stable VT, and those with hemodynamically unstable VTs were excluded. Accordingly, a monomorphic stable VT was induced in 88% of the patients matching the clinical VT in 83% of cases. With this limited ablation approach, more than a half of the patients randomized to catheter ablation had ventricular arrhythmia recurrence after 2 years of follow-up.

The limited long-term success rate with limited ablation further supports the concept that extensive endo-epicardial substrate based approaches targeting all the potential VT circuits within the scar are important to increase the procedural success in contemporary patients with infarct-related VT.

Once the results of more extensive ablation are confirmed in a multicenter randomized trial, a new study on VT ablation as first line therapy with the newer ablative technique will become necessary potentially questioning the role of ICD implantation.

In the MADIT-II trial,[6] the rate of appropriate ICD intervention for sustained ventricular arrhythmias at follow-up was about 23%. Primary VT ablation studies have demonstrated that such risk can be reduced by 32%. The systematic adoption of recently described substrate-based ablation strategies, such as endo-epicardial scar homogenization, would further reduce the risk of VT recurrence by an additional 60%. Overall, this would result in an expected drop of appropriate ICD interventions in patients similar to those enrolled in the MADIT-II to 6%. These results are remarkable, and might even question whether ICD implant is a cost-effective strategy in these patients after catheter ablation.

Conclusions

In conclusion, we believe there is evidence to support the early use of catheter ablation of VT (i.e., primary VT ablation) to decrease arrhythmia recurrence and ICD intervention in patients with coronary artery disease and malignant VAs, especially if novel and extended ablation techniques are utilized. Unfortunately, although the NNT is low, "*we are not there yet*" and ICD implantation cannot be deferred in these patients but potentially questioned. Available data do not allow conclusion on the impact of primary VT ablation on mortality and further studies are warranted.

References

1. Huikuri HV, Castellanos A, Myerburg RJ: Sudden death due to cardiac arrhythmias. N Engl J Med 2001;345:1473-1482.
2. Zipes DP, Camm AJ, Borggrefe M, Buxton AE, Chaitman B, Fromer M, Gregoratos G, Klein G, Moss AJ, Myerburg RJ, Priori SG, Quinones MA, Roden DM, Silka MJ, Tracy C, Smith SC Jr, Jacobs AK, Adams CD, Antman EM, Anderson JL, Hunt SA, Halperin JL, Nishimura R, Ornato JP, Page RL, Riegel B, Blanc JJ, Budaj A, Dean V, Deckers JW, Despres C, Dickstein K, Lekakis J, McGregor K, Metra M, Morais J, Osterspey A, Tamargo JL, Zamorano JL: ACC/AHA/ESC 2006 Guidelines for Management of Patients With Ventricular Arrhythmias and the Prevention of Sudden Cardiac Death: A report of the American College of Cardiology/American Heart Association Task Force and the European Society of Cardiology Committee for Practice Guidelines (writing committee to develop Guidelines for Management of Patients With Ventricular Arrhythmias and the Prevention of Sudden Cardiac Death): developed in collaboration with the European Heart Rhythm Association and the Heart Rhythm Society. Circulation 2006;114:e385-e484.
3. Natale A, Raviele A, Al-Ahmad A, Alfieri O, Aliot E, Almendral J, Breithardt G, Brugada J, Calkins H, Callans D, Cappato R, Camm JA, Della Bella P, Guiraudon GM, Haïssaguerre M, Hindricks G, Ho SY, Kuck KH, Marchlinski F, Packer DL, Prystowsky EN, Reddy VY, Ruskin JN, Scanavacca M, Shivkumar K, Soejima K, Stevenson WJ, Themistoclakis S, Verma A, Wilber D: Venice Chart International Consensus document on ventricular tachycardia/ventricular fibrillation ablation. J Cardiovasc Electrophysiol 2010;21:339-379.
4. Epstein AE, DiMarco JP, Ellenbogen KA,. Estes NA 3rd, Freedman RA, Gettes LS, Gillinov AM, Gregoratos G, Hammill SC, Hayes DL, Hlatky MA, Newby LK, Page RL, Schoenfeld MH, Silka MJ, Stevenson LW, Sweeney MO, Smith SC Jr, Jacobs AK, Adams CD, Anderson JL, Buller CE, Creager MA, Ettinger SM, Faxon DP, Halperin JL, Hiratzka LF, Hunt SA, Krumholz HM, Kushner FG, Lytle BW, Nishimura RA, Ornato JP, Page RL, Riegel B, Tarkington LG: Yancy CW ACC/AHA/HRS 2008 Guidelines for Device-Based Therapy of Cardiac Rhythm Abnormalities: A report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Writing Committee to Revise the ACC/AHA/NASPE 2002 Guideline Update for Implantation of Cardiac Pacemakers and Antiarrhythmia Devices) developed in collaboration with the American Association for Thoracic Surgery and Society of Thoracic Surgeons. J Am Coll Cardiol 2008;51:e1-e62.
5. Poole JE, Johnson GW, Hellkamp AS, Anderson J, Callans DJ, Raitt MH, Reddy RK, Marchlinski FE, Yee R, Guarnieri T, Talajic M, Wilber DJ, Fishbein DP, Packer DL, Mark DB, Lee KL, Bardy GH: Prognostic importance of defibrillator shocks in patients with heart failure. N Engl J Med 2008;359:1009-1017.
6. Moss AJ, Greenberg H, Case RB, Wojciech Zareba W, Hall Jackson, Brown Mary W, Daubert James P, McNitt Scott, Andrews Mark L, Elkin Adam D; for the Multicenter Automatic Defibrillator Implantation Trial-II (MADIT-II) Research Group: Long-term clinical course of patients after termination of ventricular tachyarrhythmia by an implanted defibrillator. Circulation 2004;10:3760-3765.
7. A comparison of antiarrhythmic-drug therapy with implantable defibrillators in patients resuscitated from near-fatal ventricular arrhythmias. The Antiarrhythmics versus Implantable Defibrillators (AVID) Investigators. N Engl J Med 1997;337:1576-1583.
8. Sesselberg HW, Moss AJ, McNitt S, Zareba W, Daubert JP, Andrews ML, Hall WJ, McClinitic B, Huang DT; MADIT-II Research Group: Ventricular arrhythmia storms in postinfarction patients with implantable defibrillators for primary prevention indications: A MADIT-II substudy. Heart Rhythm 2007;4:1395-1402.
9. Exner DV, Pinski SL, Wyse DG, Renfroe EG, Follmann D, Gold M, Beckman KJ, Coromilas J, Lancaster S, Hallstrom AP; AVID Investigators: Antiarrhythmics versus implantable defibrillators. Electrical storm presages nonsudden death: The antiarrhythmics versus implantable defibrillators (AVID) trial. Circulation 2001;103:2066-2071.
10. Kamphuis HC, de Leeuw JR, Derksen R, Hauer RN, Winnubst JA: Implantable cardioverter defibrillator recipients: Quality of life in recipients with and without ICD shock delivery: A prospective study. Europace 2003;5:381-389.
11. Goldenberg I, Moss AJ, Hall WJ, Zareba W, Andrews ML, Cannom DS; Multicenter Automatic Defibrillator Implantation Trial (MADIT) II Investigators: Causes and consequences of heart failure after prophylactic implantation of a defibrillator in the multicenter automatic defibrillator implantation trial II. Circulation 2006;113:2810-2817.
12. Kuck KH, Cappato R, Siebels J, Ruppel R: Randomized comparison of antiarrhythmic drug therapy with implantable defibrillators in patients resuscitated from cardiac arrest: The Cardiac Arrest Study Hamburg (CASH). Circulation 2000;102:748-754.
13. Pacifico A, Hohnloser SH, Williams JH, Tao B, Saksena S, Henry PD, Prystowsky EN: Prevention of implantable-defibrillator shocks by treatment with sotalol. d,l-Sotalol Implantable Cardioverter-Defibrillator Study Group. N Engl J Med 1999;340:1855-1862.
14. Dorian P, Borggrefe M, Al-Khalidi HR, Hohnloser SH, Brum JM, Tatla DS, Brachmann J, Myerburg RJ, Cannom DS, van der Laan M, Holroyde MJ, Singer I, Pratt CM; SHock Inhibition Evaluation with azimiLiDe (SHIELD) Investigators: Placebo-controlled, randomized clinical trial of azimilide for prevention of ventricular tachyarrhythmias in patients with an implantable cardioverter defibrillator. Circulation 2004;110:3646-3654.
15. Connolly SJ, Dorian P, Roberts RS, Gent M, Bailin S, Fain ES, Thorpe K, Champagne J, Talajic M, Coutu B, Gronefeld GC, Hohnloser SH; Optimal Pharmacological Therapy in Cardioverter Defibrillator Patients (OPTIC) Investigators: Comparison of beta-blockers, amiodarone plus beta-blockers, or sotalol for prevention of shocks from implantable cardioverter defibrillators: the OPTIC Study: A randomized trial. JAMA 2006;295:165-171.
16. Calkins H, Epstein A, Packer D, Arria AM, Hummel J, Gilligan DM, Trusso J, Carlson M, Luceri R, Kopelman H, Wilber D, Wharton JM, Stevenson W: Catheter ablation of ventricular tachycardia in patients with structural heart disease using cooled radiofrequency energy: Results of a prospective multicenter study. Cooled RF Multi Center Investigators Group. J Am Coll Cardiol 2000;35:1905-1914.
17. Kuck KH, Schaumann A, Eckardt L, Willems S, Ventura R, Delacrétaz E, Pitschner HF, Kautzner J, Schumacher B, Hansen PS; VTACH study group: Catheter ablation of stable ventricular tachycardia before defibrillator implantation in patients with coronary heart disease (VTACH): A multicentre randomised controlled trial. Lancet 2010;375:31-40.
18. Reddy VY, Reynolds MR, Neuzil P, Richardson AW, Taborsky M, Jongnarangsin K, Kralovec S, Sediva L, Ruskin JN, Josephson ME: Prophylactic catheter ablation for the prevention of defibrillator therapy. N Engl J Med 2007;357:2657-2665.

19. Epstein AE, Wilber D, Calkins H, Wharton JM, Stevenson WG, Hummel JD, Carlson KA, Ellenbogen KA, Packer DL, Kopelman HA: Randomized controlled trial of ventricular tachycardia treatment by cooled tip catheter ablation vs drug therapy. J Am Coll Cardiol 1998;31(2 Suppl A):118A.
20. Schreieck J, Schneider MAE, Röhling M, Zrenner B, Deisenhofer I, Dong J, Kolb C, von Bary C, Karch MR, Schmitt C: Preventive ablation of post infarction ventricular tachycardias: Results of a prospective randomized study. Heart Rhythm 2004;1(Suppl):S35-S7.
21. Niwano S, Fukaya H, Yuge M, Imaki R, Hirasawa S, Sasaki T, Yumoto Y, Inomata T, Izumi T: Role of electrophysiologic study (EPS)-guided preventive therapy for the management of ventricular tachyarrhythmias in patients with heart failure. Circ J 2008;72:268-273.
22. Rothman SA, Hsia HH, Cossu SF, Chmielewski IL, Buxton AE, Miller JM: Radiofrequency catheter ablation of postinfarction ventricular tachycardia: Long-term success and the significance of inducible nonclinical arrhythmias. Circulation 1997;96:3499-3508.
23. Sacher F, Tedrow UB, Field ME, Raymond JM, Koplan BA, Epstein LM, Stevenson WG: Ventricular tachycardia ablation: Evolution of patients and procedures over 8 years. Circ Arrhythm Electrophysiol 2008;1:153-161.
24. Stevenson WG, Friedman PL, Kocovic D, Sager PT, Saxon LA, Pavri B: Radiofrequency catheter ablation of ventricular tachycardia after myocardial infarction. Circulation 1998;98:308-314.
25. Strickberger SA, Man KC, Daoud EG, Goyal R, Brinkman K, Hasse C, Bogun F, Knight BP, Weiss R, Bahu M, Morady F: A prospective evaluation of catheter ablation of ventricular tachycardia as adjuvant therapy in patients with coronary artery disease and an implantable cardioverter-defibrillator. Circulation 1997;96:1525-1531.
26. Stevenson WG, Wilber DJ, Natale A, Jackman WM, Marchlinski FE, Talbert T, Gonzalez MD, Worley SJ, Daoud EG, Hwang C, Schuger C, Bump TE, Jazayeri M, Tomassoni GF, Kopelman HA, Soejima K, Nakagawa H; Multicenter Thermocool VT Ablation Trial Investigators: Irrigated radiofrequency catheter ablation guided by electroanatomic mapping for recurrent ventricular tachycardia after myocardial infarction: The multicenter thermocool ventricular tachycardia ablation trial. Circulation 2008;118:2773-2782.
27. Carbucicchio C, Santamaria M, Trevisi N, Maccabelli G, Giraldi F, Fassini G, Riva S, Moltrasio M, Cireddu M, Veglia F, Della Bella P: Catheter ablation for the treatment of electrical storm in patients with implantable cardioverter-defibrillators: Short- and long-term outcomes in a prospective single-center study. Circulation 2008;117:462-469.
28. Sosa E, Scanavacca M, d'Avila A, Pilleggi F: A new technique to perform epicardial mapping in the electrophysiology laboratory. J Cardiovasc Electrophysiol 1996;7:531-536.
29. Di Biase L, Santangeli P, Bai R, Tung R, Burkhardt JD, Shivkumar K, Natale A: Emerging role of epicardial ablation. *Contemporary Debates and Controversies in Cardiac Electrophysiology, Part II*. In: Thakur RK, Natale A, eds. Cardiac Electrophysiology Clinics 2012;4:425-437.
30. Morady F, Harvey M, Kalbfleisch SJ, el-Atassi R, Calkins H, Langberg JJ: Radiofrequency catheter ablation of ventricular tachycardia in patients with coronary artery disease. Circulation 1993;87:363-372.
31. Tung R, Josephson ME, Reddy V, Reynolds MR; Investigators S-V: Influence of clinical and procedural predictors on ventricular tachycardia ablation outcomes: An analysis from the substrate mapping and ablation in Sinus Rhythm to Halt Ventricular Tachycardia Trial (SMASH-VT). J Cardiovasc Electrophysiol 2010;21:799-803.
32. Delacretaz E, Brenner R, Schaumann A, Eckardt L, Willems S, Pitschner H-F, Kautzner J, Schumacher B, Hansen PS, Kuck KH: Catheter ablation of stable ventricular tachycardia before defibrillator implantation in patients with coronary heart disease (VTACH): An on-treatment analysis. J Cardiovasc Electrophysiol 2013;24:525-529.
33. Jais P, Maury P, Khairy P, Sacher F, Nault I, Komatsu Y, Hocini M, Forclaz A, Jadidi AS, Weerasooryia R, Shah A, Derval N, Cochet H, Knecht S, Miyazaki S, Linton N, Rivard L, Wright M, Wilton SB, Scherr D, Pascale P, Roten L, Pederson M, Bordachar P, Laurent F, Kim SJ, Ritter P, Clementy J, Haissaguerre M: Elimination of local abnormal ventricular activities: A new end point for substrate modification in patients with scar-related ventricular tachycardia. Circulation 2012;125:2184-2196.
34. Di Biase L, Santangeli P, Burkhardt DJ, Bai R, Mohanty P, Carbucicchio C, Dello Russo A, Casella M, Mohanty S, Pump A, Hongo R, Beheiry S, Pelargonio G, Santarelli P, Zucchetti M, Horton R, Sanchez JE, Elayi CS, Lakkireddy D, Tondo C, Natale A: Endo-epicardial homogenization of the scar versus limited substrate ablation for the treatment of electrical storms in patients with ischemic cardiomyopathy. J Am Coll Cardiol 2012;60:132-141.
35. Vergara P, Trevisi N, Ricco A, Petracca F, Baratto F, Cireddu M, Bisceglia C, Maccabelli G, Della Bella P: Late potentials abolition as an additional technique for reduction of arrhythmia recurrence in scar related ventricular tachycardia ablation. J Cardiovascular Electrophysiology 2012;23:621-627.