# Idiopathic Left Ventricular Tachycardia with a Right Bundle Branch Block Morphology and Left Axis Deviation ("Belhassen type"): Results of Radiofrequency Ablation in 18 Patients

Ian Topilski MD, Aharon Glick MD and Bernard Belhassen MD

Department of Cardiology, Tel Aviv Sourasky Medical Center, Tel Aviv, Israel
Affiliated to Sackler Faculty of Medicine, Tel Aviv University, Ramat Aviv, Israel

**Key words:** ventricular tachycardia, radiofrequency ablation

## Abstract

**Background:** Idiopathic left ventricular tachycardia with a right bundle branch block configuration and left axis deviation, first described by Belhassen et al., is a rare electrocardiographic-electrophysiologic entity. Radiofrequency catheter ablation has been proposed as a good therapeutic option, but the best criteria for determining the optimal site of ablation are still under debate.

**Objectives:** To report the clinical features, electrophysiologic characteristics, results of RFA, and long-term outcome in 18 patients with "Belhassen's VT" treated in our laboratory during the last 10 years, stressing the best electrophysiologic criteria for determining the optimal site of ablation.

**Methods:** Eighteen consecutive patients with this specific VT underwent RFA in our laboratory during the last 10 years. RFA was acutely successful in 17 patients after one or two procedures (15 and 2 patients, respectively) using 4.1 $\pm$ 2.2 RF pulses. The putative ablation sites were defined by good pace-mapping (3 patients), earliest recorded Purkinje spike prior to the QRS onset during VT or sinus rhythm (6 patients), earliest endocardial activation during VT (1 patient), and diastolic potential preceding the Purkinje spike during VT and/or late diastolic potential in sinus rhythm (7 patients). In the patients with a definite successful ablation, the ratio of successful to unsuccessful radiofrequency pulse delivery to the diastolic potential site was compared to that of other methods. The ratio of successful RFA at the diastolic potential site (5:8) was higher than in the other methods (8:31) and the difference was statistically significant ($P$ = 0.05). Successful ablation sites were more basal when the diastolic potential site was chosen.

**Conclusion:** The results of the present study confirm the high success rate and safety of RFA using conventional techniques in the management of "Belhassen VT," suggesting that this procedure can be used as a first-line therapy. Ablating at a site demonstrating a late diastolic potential is at least as effective as ablating at a ventricular exit site, although the use of combined electrophysiologic criteria may be the optimal approach.

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RFA = radiofrequency catheter ablation
VT = ventricular tachycardia

Sustained monomorphic ventricular tachycardia is most often associated with structural heart disease such as healed myocardial infarction. However, VT without demonstrable heart disease ("idiopathic VT") comprises approximately 10% of all encountered cases of sustained monomorphic VT [1]. The most common type of idiopathic VT (approximately 80%) originates from the outflow tract of either a ventricle or a coronary cusp. The remaining types comprise VTs originating close to the left posterior fascicle or, more rarely, the left anterior fascicle.

The 12-lead electrocardiogram of the left posterior type of idiopathic VT shows a right bundle branch block morphology and left axis deviation. More than 20 years ago, our group [2,3] was the first to describe the unique responsiveness of this VT to intravenous verapamil, which invariably results in progressive slowing and subsequent termination of the tachycardia. This type of VT has been observed throughout the world, with a disproportionate number of reports originating from Southeast Asia [4–7]. It mainly affects male patients [8], aged 20–40 years old when first studied but who frequently suffer their first VT episodes during adolescence. Patients usually present with hemodynamically well-tolerated episodes of sustained monomorphic VT at rates ranging from 150 to 220 beats/minute. Common precipitating factors include febrile illness, exercise or excitement. Misdiagnosis of the arrhythmia as a supraventricular tachycardia with aberration is frequent. Premature ventricular complexes are typically absent between VT episodes. Transient repolarization abnormalities are common in inferolateral leads after VT termination due to the "cardiac memory" phenomenon.

The clinical VT is usually easily induced (sometimes after catecholamine infusion) and terminated with rapid ventricular pacing. A typical feature of this arrhythmia is its inducibility with rapid atrial pacing. The mechanism of VT is assumed to be macroreentry within the Purkinje network in most patients [9–11], although in rare cases triggered activity could be operative [1]. During left ventricular endocardial mapping, a "Purkinje spike" can usually be identified preceding the onset of the QRS complex in both VT and sinus rhythm [12–14], and more recent reports have identified a retrograde activation of the posterior Purkinje fiber [11] or a late diastolic potential [13,15,16] as critical components of the

reentrant circuit. The site of VT origin is usually the infero-septo-apical area of the left ventricle [3,12].

The prognosis of VT is generally excellent [17,18], with rare reports of cardiac deterioration or sudden cardiac death [1]. Thus, patients with rare and well-tolerated episodes of tachycardia do not require prophylactic therapy and are treated with intravenous verapamil in case of arrhythmic event. For patients with drug-refractory arrhythmias or those unwilling to take long-term medications, radiofrequency catheter ablation has proven to be a good therapeutic option [6,7,12,19,20].

The purpose of the present study is to report the clinical features, electrophysiologic characteristics, results of RFA and long-term outcome of 18 patients with "Belhassen's VT" treated in our laboratory during the last 10 years. Special attention has been given to the best electrophysiologic criteria for determining the optimal site of ablation.

## Patients and Methods

### Patient characteristics

Between January 1992 and July 2003, 151 patients with various types of ventricular arrhythmias underwent RFA in our laboratory. Of these, 18 (12%) had monomorphic VT with a morphology of RBBB and left axis deviation in the absence of demonstrable heart disease [Figure 1]. The administration of verapamil during previous VT episodes was not a prerequisite for patient inclusion in the study. All patients had ECG recordings of sustained (lasting $\geqslant$ 30 seconds) or non-sustained (lasting <30 seconds) VT. All had normal physical examination, resting ECG [Figure 1] – except for occasional transient inferior repolarization abnormalities – and echocardiogram. There was no suspicion of myocardial ischemia in the patients who underwent exercise test or Thallium test, or significant coronary abnormalities in the patients who underwent coronary angiography.

### Electrophysiologic testing and catheter ablation

Two patients underwent RFA while being treated with amiodarone. In the remaining 16 patients, all anti-arrhythmic medications were discontinued for 48 hours before the procedure. After informed consent was obtained, the electrophysiologic study was performed using standard techniques. Three 6-French quadripolar electrode catheters were introduced percutaneously through the right femoral vein and positioned in the right ventricular apex, His bundle area, and high right atrium, respectively, for recording and pacing. Another 7-French quadripolar steerable ablation catheter (EP Technology Inc., USA) was inserted through the right femoral artery, advanced retrogradely across the aortic valve, and positioned at the left interventricular septum. Intravenous heparin was administered at an initial bolus dose of 5,000 units, followed by 1,000 units/hour. Programmed stimulation and rapid pacing were performed from the right atrial, right ventricular apex (or outflow tract if necessary) or left ventricular apex to induce VT. Programmed ventricular stimulation included up to three extrastimuli at two cycle lengths. If sustained VT was not induced, the protocol was repeated after isoproterenol was administered at incremental dosage until the basic sinus rhythm increased up to 150/min. Radiofrequency energy was delivered with a temperature setting of 72°C delivered during 30–60 seconds. Administration of radio-frequency energy was discontinued upon occurrence of impedance rise, catheter displacement or severe chest pains. The putative ablation sites were defined by one or several of the following: good pace-mapping ($\geqslant$ 11/12 ECG lead concordance of the major and minor deflections of the recordings during VT), earliest recorded Purkinje spike prior to the QRS onset during VT or sinus rhythm, earliest endocardial activation during VT, and diastolic potential preceding the Purkinje spike during VT and/or late diastolic potential in sinus rhythm. The VT "exit site" of the reentry mechanism was defined by the site of earliest endocardial activation or earliest Purkinje potential during VT, or the site of optimal pace-mapping [12]. After ablation, programmed cardiac stimulation was performed using the same protocol as previously described, before and after isoproterenol infusion. Patients were followed in our outpatient clinic or by the referring physician, and were contacted by telephone.

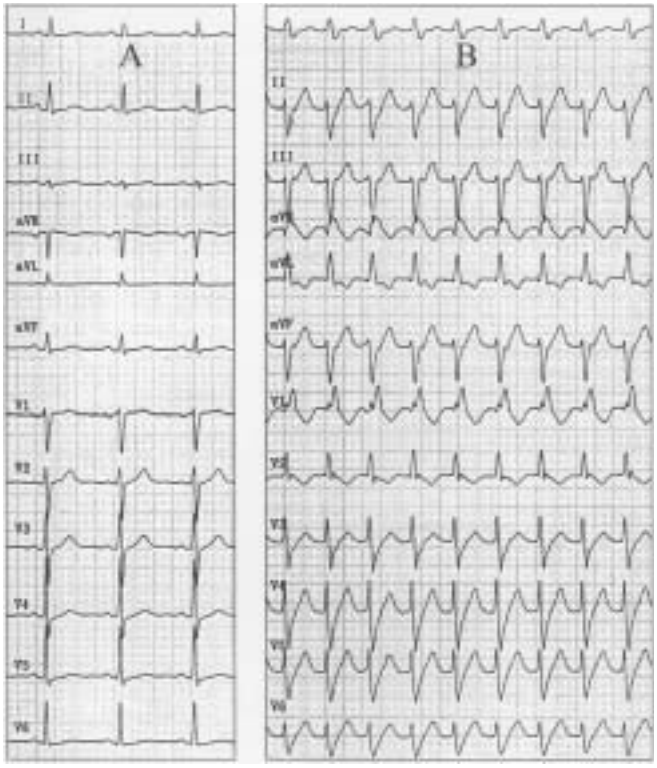


**Figure 1.** Patient 4. Twelve-lead ECG tracings during sinus rhythm **[A]** and sustained VT induced during electrophysiologic study **[B].** During sinus rhythm at 75/min, normal QRS complexes are present. During VT at 130/min, the QRS complexes have a morphology of RBBB and a left axis deviation; note the presence of atrioventricular dissociation with a sinus P wave preceding the third QRS complex of the tachycardia. This patient is the one previously published in our initial report [2].

### Statistical analysis

Values were expressed as mean standard deviation. Student's *t*-test was used to compare parametric data. The chi-square test was used

RBBB = right bundle branch block

to compare non parametric data. A $P$ value <0.05 was considered statistically significant.

## Results

### Patients' clinical characteristics

There were 16 men and 2 women, ranging in age from 16 to 56 years (mean 32 ± 11). Seven patients were Ashkenazi Jews (East European origin), four were Sephardi Jews (Middle East or North African origin), and seven were Arabs. Nine patients were referred to us by physicians from other hospitals. No family clusters were found. Fifteen patients suffered from recurrent palpitations, 2 patients suffered from dizziness, and 1 patient was asymptomatic and had his arrhythmia diagnosed during a routine exercise test. The duration of patients' symptoms ranged from 22 years to a few weeks (mean 5.9 ± 6.3 years). The index VT that led to electrophysiologic study and ablation was the first documented tachycardia episode in three patients. In 12 patients VT occurred without an obvious precipitating cause; 2 patients had VT triggered by fever, while 4 patients had VT induced only during exercise test performed for investigation of palpitations. VT was sustained in 11 patients but not in 7. The spontaneous VT rate ranged from 120 to 220 beats/min (mean 179 ± 28). Intravenous verapamil had been previously given during spontaneous VT in eight patients and terminated it in all cases. Six patients had been given intravenous amiodarone, but the latter terminated VT in only two instances. Intravenous adenosine triphosphate, given in five patients, terminated VT in only one patient. Intravenous flecainide and propafenone terminated VT in one of three patients and one of two patients, respectively. Lidocaine was unsuccessful in two patients. During the first documentation of the arrhythmia, the latter was misdiagnosed as supraventricular tachycardia with aberration in 4 (22%) of the 18 patients. The QRS during VT was monomorphic in 16 patients [Figures 1 and 2], while it was pleomorphic with QRS alternans in 2 patients [Figure 3]. One patient was the subject of our first description in 1981 [2]. None of the other patients have been previously reported.

### Electrophysiologic results

During baseline electrophysiologic testing, VT was induced in 7 patients (39%). After isoproterenol infusion, VT was induced in 7 additional patients (39%), while in 1 patient (5.5%) VT occurred spontaneously during the washout period following drug discontinuation. VT was not induced, or spontaneously occurred, in 3 patients (16.5%) before and after isoproterenol infusion; in these three patients, single ventricular beats resembling the clinical VT could be induced and were used for guiding the ablation procedure. The VTs induced during the electrophysiologic study were sustained in 12 patients (66%). VT rate during electrophysiologic study ranged between 120 and 220 beats/min (mean 178 ± 33) and was positively correlated with the spontaneous VT rate ($r$ = 0.78, $P$ = 0.001). Supraventricular tachycardia was induced during the course of electrophysiologic study in four patients: slow/fast atrioventricular nodal reentrant tachycardia in two patients, atrial tachycardia in one, and atrial fibrillation persisting throughout the RFA in one. In one patient, a left fascicular VT originating close to the anterior fascicle (RBBB with right axis deviation) was also induced.

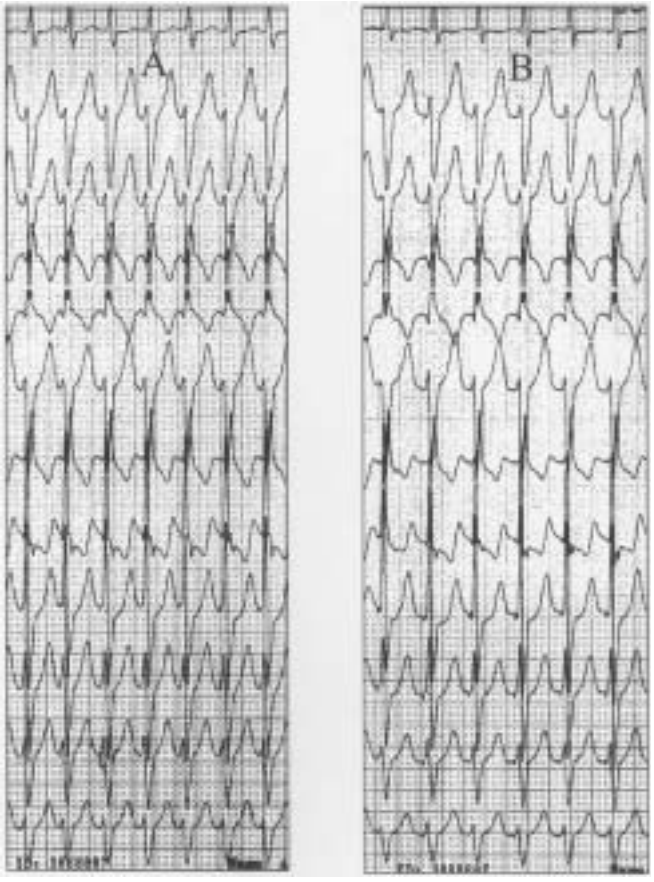


**Figure 2.** Patient 13. Twelve-lead ECG tracings: **[A]** during sustained VT (160/min) induced at electrophysiologic study and **[B]** during pacing (140/min) at the infero-septo-apical area of the left ventricle. Note that pace-mapping results in perfect (12/12) ECG lead correlation as compared with induced VT. Radiofrequency ablation administered at this site resulted in abolition of VT.

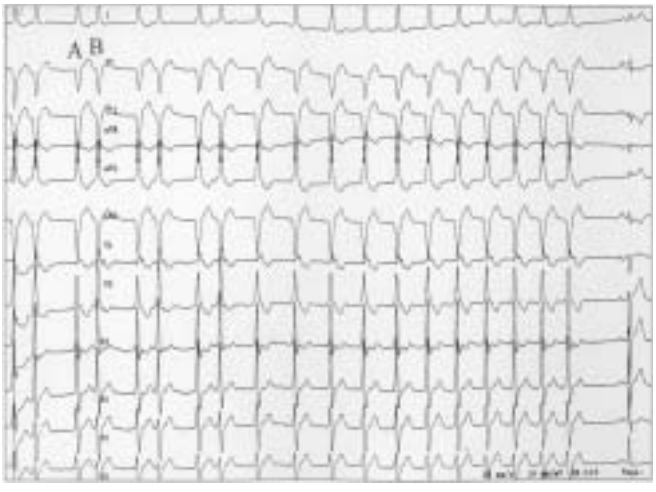


**Figure 3.** Patient 9. Twelve-lead ECG tracings during successful radiofrequency ablation of sustained pleomorphic VT (130/min) with cycle length alternans at an infero-septo-apical area of the left ventricle. In this patient the spontaneous and induced VT was constituted by a succession of slightly different (type A and type B) and alternant (AB < BA) complexes with a RBBB morphology and left axis deviation. During the successful radiofrequency pulse, note that the type B complexes are abolished before the type A complexes.

### Results of catheter ablation

In the first patient studied, no radiofrequency pulse was administered due to inaccurate pace-mapping data and lack of recording of Purkinje spikes. Catheter ablation was acutely successful in all the remaining 17 patients after one or two RFA procedures (15 and 2 patients, respectively). The mean pulse number required for successful ablation was 4.1 $\pm$ 2.2 pulses. A successful ablation site was defined by pace-mapping alone in 3 patients (17.5%) [Figure 2], pace-mapping and recorded Purkinje spike before the onset of QRS during VT or sinus rhythm in 6 patients (35.5%), earliest endocardial activation during VT and pace-mapping in 1 patient (6%), and at the site of registered mid-diastolic potential preceding the Purkinje spike or late diastolic potential in sinus rhythm in 7 patients (41%) [Figure 4]. In the patients with inducible VT and a definite successful ablation, the ratio of successful to unsuccessful radiofrequency pulse delivery to the VT "exit site" was compared to that during which pulse energy was applied to the diastolic potential site. The ratio of successful RFA in the diastolic potential site (5:8) was higher than in the "exit site" (8:31), and the difference was statistically significant ($P$ = 0.05). The successful ablation sites were located in the infero-septo-apical area of the left ventricle in 12 patients (70.5%) and in the mid-septal area of left ventricle in 5 patients (29.5%). Successful ablation sites were more basal when the diastolic potential site was chosen. The difference in anatomic ablation site in the two groups reached statistical significance ($P < 0.05$).

All patients but one underwent uncomplicated procedures. In the latter, iatrogenic ventricular fibrillation requiring direct current shock occurred, without any long-term complications.

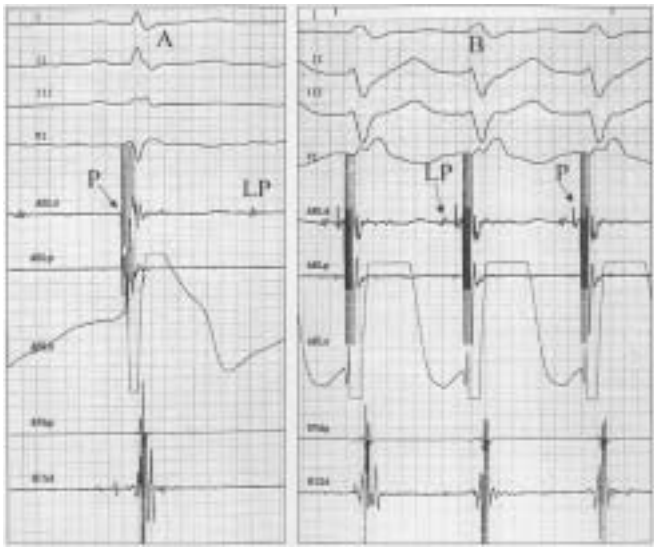


**Figure 4.** Patient 4. Intracardiac recordings during sinus rhythm **[A]** and induced sustained VT (152/min) **[B]** at a mid-septal area of the left ventricle, where radiofrequency ablation resulted in abolition of VT and pace-mapping resulted in poor (6/12) ECG lead correlation. Note the recording from the ablation catheter: a) in sinus rhythm, the presence of a Purkinje potential (P) preceding by 10 msec the onset of the QRS complex and a late potential (LP) occurring 450 ms after the Purkinje potential; b) during VT, the presence of the LP preceding the Purkinje potential and the onset of the QRS complex by 50 ms and 80 ms, respectively. Also note a RBBB in sinus rhythm due to catheter-related trauma.
ABLd and ABLp = bipolar recordings from the distal and proximal pairs of the ablation catheter, respectively; ABLu = unipolar recording of the distal activity of the ablation catheter; RVAp and HISd = recordings of the electrical activity of the right ventricular apex and the distal activity of the His bundle, respectively.

### Follow-up

Following a single ablation (n=14) or two ablation (n=2) procedures, no VT was documented (ECG or Holter) or induced during exercise test in 16 of 17 patients after a follow-up period ranging from 1 to 122 months (41.3 $\pm$ 35.2). In one patient who had sustained pleomorphic VT before RFA, short bouts of non-sustained VT of a single morphologic type were recorded 2 months after ablation.

## Discussion

We present a consecutive series of 18 patients who had idiopathic monomorphic VT with a morphology of RBBB and left axis deviation and underwent RFA of their arrhythmia in our laboratory. Although we would have preferred including only those patients who exhibited the two features reported in our initial description [2] (i.e., specific ECG pattern and response to verapamil), we decided that the administration of verapamil during previous VT episodes should not be a prerequisite for patient inclusion. This decision was based on the following: a) only 8 of our 18 patients were given intravenous verapamil before referral to RFA, which would have considerably reduced the size of our study group; b) testing the effects of verapamil during the course of RFA would have rendered the latter very difficult, since it is highly likely that verapamil would have terminated VT and prevented its subsequent inducibility; and c) a review of the literature on patients with idiopathic left VT and a morphology of RBBB and left axis deviation showed that, except for a single patient reported by our group [21], intravenous verapamil terminated VT in all patients in whom it was administered. This confirms that we are actually dealing with a unique ECG-electrophysiologic entity, as we postulated more than 20 years ago [2,3].

### Clinical characteristics

The clinical characteristics of our patients confirm previous reports on the male prevalence of this type of VT. In a recent analysis of 227 patients collected from the literature, Nakagawa et al. [8] reported a male/female ratio of 3.4 while an even greater male/female ratio of 8 was found in our study. With regard to the ethnic origin of our patients, we found a high proportion of Arab patients (39%), which represents a prevalence twofold higher than in the Israeli population. It is likely that this finding merely reflects a referral bias. Another interesting point in our study was the relatively low percentage of patients (22%) misdiagnosed as having supraventricular tachycardia with aberration, as compared to higher figures reported in other studies [1]. This relatively low incidence of wrong diagnosis could be related to a good knowledge in the medical community in our country regarding this specific type of VT.

**Results of electrophysiologic study and ablation**

We found that 83% of patients had VT induced with or without isoproterenol, and that the induced VT had a morphology and rate similar to that of spontaneously occurring VT. These results are consistent with those reported by others [4–6,17,19]. Interestingly, we found that supraventricular tachycardia coexisted in 22% of our patients. While the occurrence of atrial fibrillation in one patient could be related to the aggressive stimulation protocol used, the other supraventricular tachycardias deserve further investigation as to a potential connection between them and the VT episodes [21,22]. In our study, ablation of the VT was acutely achieved in 95% of the patients. Such a result is comparable to the 75–100% success rate obtained by other groups [6,7,12,16,19]. In order to determine the optimal ablation site, we used a combination of methods. In early studies, the earliest endocardial activation site during VT, together with good pace-mapping ($\geqslant$ 11/12 correlation), was described as the best method for finding the VT exit site [6,19]. Later, Nakagawa and colleagues [12] emphasized the importance of recording Purkinje potentials for ablating this type of tachycardia. These researchers found that ablation at the earliest Purkinje potential (which invariably preceded the QRS during VT and probably represents the fascicular potential in the ventricular exit site) was highly successful. More recent work by Tsuchiya et al. [16] suggested that the presence during VT of a late diastolic potential preceding the Purkinje potential may represent an electrical activity related to the reentry circuit, and thus may be a better marker for successful RFA. While ablation sites defined by pace-mapping, early endocardial activation, or early Purkinje potentials are related to the ventricular exit site of the tachycardia, late diastolic potentials probably reflect the excitation within the critical slow conduction area participating in the reentry circuit. In our study, we found that ablating at a site demonstrating a late diastolic potential was at least as effective as ablating at a ventricular exit site, although the use of combined electrophysiologic criteria may be the optimal approach. In addition, we found that successful ablation at a late diastolic potential site was achieved at the mid-septal area of the left ventricle, while successful ablation at sites defined by the other methods was achieved at the infero-septo-apical area of the left ventricle. These results are in concordance with those found by Tsuchiya et al. [16], who showed that ablation sites selected by the presence of a late diastolic potential were more basal in the left ventricle than ablation sites localized at the VT exit site.

No significant complications were observed in our patient group, confirming the safety of the procedure. However, great care should be taken when RF pulses are administered at the left mid-septal area in order to avoid damage to the atrioventricular conduction system.

## Conclusion

The results of the present study confirm the high success rate and safety of RFA using conventional techniques in the management of "Belhassen VT," suggesting that this procedure can be used as a first-line therapy.

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**Correspondence:** Dr. B. Belhassen, Cardiac Electrophysiology Laboratory, Dept. of Cardiology, Tel Aviv Sourasky Medical Center, 6 Weizmann Street, Tel Aviv 64239, Israel.
Tel/Fax: (972-3) 697-4418
email: bblhass@tasmc.health.gov.il