Comparison between Local Abnormal Ventricular Activities (LAVA) Elimination vs. Scar-Dechanneling as two Substrate-Based Approaches for Ablation of Scar-Related Ventricular Tachycardia

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Abstract:

Background: Substrate-based approaches for ablation of scar-related ventricular tachycardia (VT) can help overcome the challenges of conventional mapping techniques particularly in VT storm patients.

Objective: We aimed to compare the outcomes of scar dechanneling vs. local abnormal ventricular activity (LAVA) elimination for ablation in our patient cohort who were predominantly presenting with VT storm.

Methods and Results:

In our prospective observational study, we have enrolled 30 consecutive patients (mean age 58.13 years) with scar-related VT (90% had VT storm). We used either the scar dechanneling (in 14 patients) or the LAVA elimination (in 16 patients) method. No significant difference was found between the two groups regarding the median procedure duration (192 vs 157 minutes in the LAVA and dechanneling groups respectively, p value 0.142), the median number of ablation points (74 points in each group, p value 0.93) or the acute procedural success rate (87.5% and 78.5% in the LAVA and dechanneling groups respectively, p value 0.642). At 12 months follow up, the overall recurrence rate was comparable in both groups (62.5% and 50% in the LAVA and dechanneling groups respectively, p value 0.491). VT storm recurrence was 12.5% in the LAVA group compared to 35.5% in the dechanneling group (p value 0.404), a relatively good figure considering that at baseline 90% of patients had VT storm.

Conclusion:

LAVA elimination and scar dechanneling are two comparable methods regarding efficacy and safety in ablation of scar-related VT. Both have been associated with high acute success rates in VT storm patients.

Key words: ventricular tachycardia, storm, ablation, scar dechanneling, local abnormal ventricular activity

Introduction:

Sustained ventricular tachycardia (VT) is a notable cause of morbidity and mortality in patients with structural heart disease. With the continued development of ablation strategies and technologies, catheter ablation has become a rapidly rising tool in the management of scar-related VT. Ablation targets a critical isthmus to interrupt the re-entrant circuit. This requires the VT to be reliably inducible, hemodynamically well-tolerated, and of a single morphology, allowing for activation and entrainment mapping. Challenging enough, this is not the case in many circumstances. which renders these classic techniques less tempting especially in critically ill patients.[1]

Consequently, in the past few years, several substrate-based approaches have been developed and gained popularity. These aim at overcoming the above-mentioned challenges and pursue better short and long-term results. These include scar dechanneling, core isolation, ablation of local abnormal ventricular activities (LAVA) and scar homogenization [2]. We **aimed** to to compare the outcomes of scar dechanneling and LAVA elimination in a critical cohort of patients who were predominantly (90% of them) presenting with VT storm.

Patients and Method

This prospective observational study was conducted on thirty consecutive patients undergoing ablation for scar-related ventricular tachycardia (VT) at Ain Shams University hospitals; in the period between June 2018 till June 2020, after gaining approval from the faculty medical ethical committee and obtaining informed written consents from participant patients.

All patients had structural heart disease (SHD) ; either ischemic or non-ischemic cardiomyopathy presented with recurrent sustained VT despite antiarrhythmic drug therapy requiring multiple cardioversions; either external or internal in patients with implantable cardioverter defibrillators (ICD). Patients with VT attributable to transient or reversible causes were excluded (Figure 1).

Pre-procedural evaluation:

The 12-lead surface ECG of the tachycardia, if available, was evaluated to determine the possible exit site of the clinical VT. Kuchar et al proposed an algorithm for that.[3]Antiarrhythmic medications (including amiodarone) were planned to be continued till the procedure.

LV access & Electrophysiological procedure:

The electrophysiological study and ablation were conducted under general anesthesia or occasionally conscious sedation under supervision of an anesthesiologist. Non-invasive or intra-arterial blood pressure monitoring and digital pulse oximetry were performed continuously. ICD therapies were planned to be inactivated in all patients during the procedure.

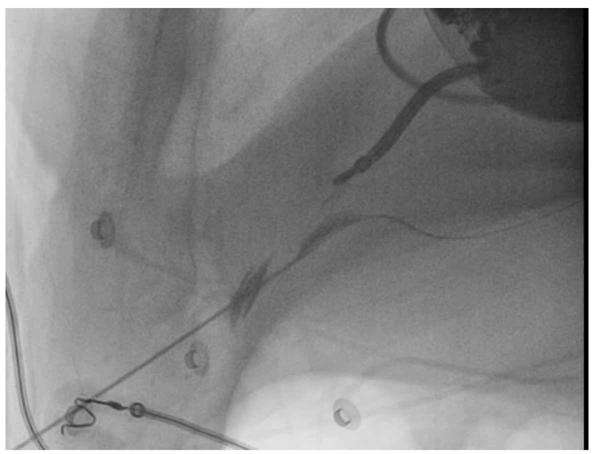
Vascular access was obtained through the right femoral vein and right femoral artery. A quadripolar (either St. Jude medical or Biosense Webster) and a steerable decapolar catheter were positioned in the right ventricular (RV) apex and coronary sinus; respectively. The left ventricle (LV) was accessed by retrograde and/or transeptal approaches. The mode of access to the LV was done at the operator's discretion. Catheters were introduced under fluoroscopic guidance. Upon attaining LV access, a 100 U/kg heparin bolus was administered intravenously and repeated as necessary with a target activated clotting time (ACT) of >250 seconds.

Pericardial approach:

This was done if the patient had features beforehand suggesting an epicardial origin of the VT substrate such as having non-ischemic cardiomyopathy or surface ECG features of the clinical VT suggesting an epicardial origin of the VT [4 5]. In addition, it was performed if endocardial mapping did not reveal significant scar or delayed potentials that could constitute targets for ablation.

Access was obtained through a sub-xiphoid pericardial puncture following the classic technique proposed by Sosa et al. An anterior approach to the RV was preferred.[6,7]

Figure (2) Lateral view showing guidewire passage through the epicardial needle into the pericardial space; posterior approach.



Mapping protocol:

High-density electroanatomic voltage map of the LV was created during sinus rhythm in all patients using the CARTO 3 system version 6 (Biosense Webster, Diamond Bar, CA). Bipolar electrograms were filtered from 30 to 250 Hz. At the endocardial area, scar areas were identified using standard voltage cut-off values for dense scar (<0.5 mV) and border zones; BZ (<1.5mV). At the epicardial surface, low voltage areas were identified as having bipolar voltage amplitude of < 1mV.

Afterwards, further mapping and ablation was done either by the scar dechanneling technique or by local abnormal ventricular activity (LAVA) elimination.

Surface electrocardiograms (ECGs) and bipolar intracardiac electrograms were continuously monitored on the St. Jude EP Lab System (Workmate Claris). Signals were sampled at 1 kHz and filtered at 0.1-50 Hz for surface ECGs and 30-400 Hz for intracardiac signals, displayed at an amplification of 0.1 mV/cm.

I- Local abnormal ventricular activity (LAVA) elimination:

During creation of the voltage map, we sought to identify and target the areas displaying LAVA with particular focus at potential sites as predicted from the surface ECG of the VT as well as at low voltage areas. LAVA were defined as sharp high frequency usually low amplitude signals distinct from the far field electrogram components, that show fractionation, double or delayed components separated by isoelectric intervals. These were located during or after the ventricular electrogram during sinus rhythm, while preceding the ventricular electrogram during the VT. LAVA are also characterized by being poorly coupled from the rest of the myocardium as identified by certain pacing maneuvers.[8]

Ablation at LAVA sites during sinus rhythm was done using a 3.5 mm externally irrigated-tip catheter. Radiofrequency energy with a power of 25 to 50 W was delivered at sites displaying LAVA with resultant abolition, delay or dissociation of these potentials.

II- Scar Dechanneling method:

During constructing the voltage map; within the border zone, we aimed to identify a corridor of electrograms with delayed components (E-DCs) that were then dichotomously classified into entrance or inner conducting channels (CCs) according to the precocity of post-systolic potential during sinus rhythm. The CC entrance was identified as the E-DC with the shortest delay between the main ventricular component (high amplitude low frequency) and the delayed component (delayed sharp high frequency low amplitude) (figure 4).

Next, we performed radiofrequency (RF) ablation of all entrance CCs aiming at elimination of all CCs using an externally irrigated 3.5-mm tip ablation catheter (Thermocool, Navistar, Biosense Webster) with 50-W power limit, 45°C temperature control, and 26 to 30 mL/min irrigation rate (40 W and 17 mL/min at epicardium). Each RF application lasted 30-60 seconds, till elimination of the DC, and we checked whether these electrograms were abolished with the ablation catheter. When needed, we performed a new application at the closest site having CC-entrance characteristics until there was entrance block. CC entrance abolition was considered to have been successfully achieved if there was disappearance of inner CCs, there was automaticity with exit block or if activation sequence of inner CCs has become in the reverse order.

Final remap & post ablation study:

Finally, programmed stimulation was done from the RV apex and/or the LV, both by burst pacing and extrastimulation (up to three extrastimuli). In case VT is induced, it was terminated either by overdrive pacing or by delivering a shock (either external or from the ICD). Then, if that VT was considered to be clinical/probably clinical, remapping was done with a view for ablation either by abolition of residual CCs in case of the dechanneling method or by elimination of residual LAVA in the other group. This was sometimes combined with brief activation map along with pace mapping. However, if the patient's clinical condition was deemed unstable, VT induction was avoided for patient safety issues.

In our study, procedural success was considered as failure of induction of any VT that is clinical/probably clinical by programmed stimulation.

Follow up:

Pre-procedural antiarrhythmics were generally continued unless contraindicated. Patients were followed up at three months and 12 months post-ablation. ICDs were interrogated for detection of any VT episodes, appropriate ICD therapies (either ATP/shocks). The very few patients without ICDs were subject to detailed history taking, ECGs and Holter when needed. Doses of antiarrhythmic medications were recorded as well as heart failure functional class, hospitalization and mortality.

Data Management and Analysis:

The collected data was revised, coded, tabulated, and introduced to a PC using Statistical package for Social Science (SPSS 25). Data was presented and suitable analysis was done according to the type of data obtained for each parameter; mean, standard deviation (± SD) and range for parametric numerical data, while Median and Interquartile range (IQR) were used for non-parametric numerical data. Frequency and percentage were used for non-numerical data. Student T-test was used to assess the statistical significance of the difference between two study group means. ***Mann Whitney Test (U test)*** was used to assess the statistical significance of the difference of a non-parametric variable between two study groups. ***Chi-Square test*** was used to examine the relationship between two qualitative variables. ***Fisher's exact test*** was used to examine the relationship between two qualitative variables when the expected count is less than 5 in more than 20% of cells.

Results:

The study population was divided into two groups based on the technique of mapping and ablation; namely local abnormal ventricular activity (LAVA) elimination and scar dechanneling. The baseline demographic data, clinical data as well as patient clinical presentation are presented in **table (1).** None of these variables showed significant difference between the two groups. It is worth noting that 90% of our patients had a VT storm in the month prior to their presentation, which is a relatively large proportion of patients compared to other studies.

Table (1)1: Demographic and clinical data and clinical presentation in the two groups.

	Technique		
	LAVA (N=16)	Dechannelling (N=14)	p-Value
Age, years Mean (SD)	56.44 ± 13.97	60.07 ± 11.47	0.447
Males, N (%)	14 (87.5%)	14 (100%)	0.485
Smoker#, N (%)	4 (25%)	5 (35.71%)	0.694
Diabetes#, N (%)	6 (37.5%)	4 (28.57%)	0.709
Hypertension#, N(%)	3 (18.75%)	6 (42.86%)	0.236
Serum creatinine* (mg/dl) Mean ±SD	1.15 ± 0.25	1.28 ± 0.33	0.256
Etiology of heart disease, N (%)			
-ICM	8 (50%)	11 (78.57%)	0.188
-DCM	7 (43.75%)	3 (21.43%)	
-VHD surgery	1 (6.25%)	0 (0%)	
Previous Cardiac surgery, N (%)			0.783
-CABG	1 (6.25%)	2 (14.29%)	
-Valvular	1 (6.25%)	1 (7.14%)	0.783
LVEF% (mean± SD)	34.94 ± 11.13	30.14 ± 7.06	0.177
PAINESD score (median± IQR)	8 (5.5 - 15.5)	11.5 (11 - 17)	0.053
Cardiac device implanted, N (%)			
-CRT-P	1 (6.25%)	0 (0%)	0.44
-Single chamber ICD	4 (25%)	4 (28.57%)	
-Dual chamber ICD	6 (37.5%)	2 (14.29%)	
-CRT-D	4 (25%)	5 (35.71%)	
Clinical presentation, N (%) VT Storm	14 (87.5%)	13 (92.8%)	1

*Student t-test (t= Student t-test value). *Mann-Whitney test (U= Mann-Whitney test value).
Fisher's exact test.
CABG: coronary artery bypass graft, CRT-D: cardiac resynchronization therapy-defibrillator; CRT-P: cardiac resynchronization therapy-pacemaker. DCM cardiomyopathy: dilated cardiomyopathy. ICD: implantable cardioverter defibrillator. ICM: ischemic cardiomyopathy. LAVA: Local abnormal ventricular activity, LVEF: left ventricular ejection fraction. N: number of patients. SD: standard deviation. VHD: valvular heart disease. VT, ventricular tachycardia

Procedural data:

ISSN:0975-3583,0976-2833 VOL12,ISSUE05,2021

No significant difference was found between the two groups regarding the procedural data (table 2). Figures (3) and (4) demonstrate examples of maps done and electrograms recorded from both groups. Epicardial access was mostly adopted in patients with dilated cardiomyopathy in which significant component of the substrate was expected to lie epicardially. Two patients in the LAVA group were not subject to arrhythmia induction at the end due to prolonged procedure time and patient clinical instability.

Concerning the dechanneling group, VT was still inducible at the end of the procedure in one patient, while in the other two cases, we decided not to do induction due to development of acute pulmonary edema in one patient and prolonged procedure time and development of recurrent VT & shocks in the other with requirement for incremental doses of vasopressors.

Table (2): Procedural data in the two groups.

	Technique		
	LAVA (N=16)	Dechannelling (N=14)	p-Value
Access. N (%)			0.44
-Endocardial	10 (62.5%)	11 (78.57%)	
-Endocardial and Epicardial	6 (37.5%)	3 (21.43%)	
Pattern and site of scar. N (%)			0.948
-Anteroseptal and apical	6 (37.5%)	7 (50%)	
-Inferolateral	6 (37.5%)	4 (28.57%)	
-Perimitral & outflow	2 (12.5%)	1 (7.14%)	
-Anteroseptal, apical & Inferolateral	2 (12.5%)	2 (14.29%)	
Procedural time (minutes) (mean ± SD)	192.5 ± 83.31	157.14 ± 38.11	0.142
Mapped points. N Median (IQR)	440 (262.5 - 708.5)	358.5 (205 - 757)	0.299
RF ablation points. N Median (IQR)	74 (52 - 95)	74 (49 - 142)	0.934
Scar area (%)	28 (15.5 - 40.5)	29.5 (24 - 35)	0.950
Contact force	1 (6.25%)	3 (21.43%)	0.315
Endpoint. N(%)			
-No induction of VT	14 (87.5%)	11 (78.57%)	0.642
-Endpoint not achieved	2 (12.5%)	3 (21.43%)	

*Student t-test (t= Student t-test value). *Mann-Whitney test (U= Mann-Whitney test value). LAVA: Local abnormal ventricular activity, N: number of patients. RF: radiofrequency. SD: standard deviation

ISSN:0975-3583,0976-2833 VOL12,ISSUE05,2021

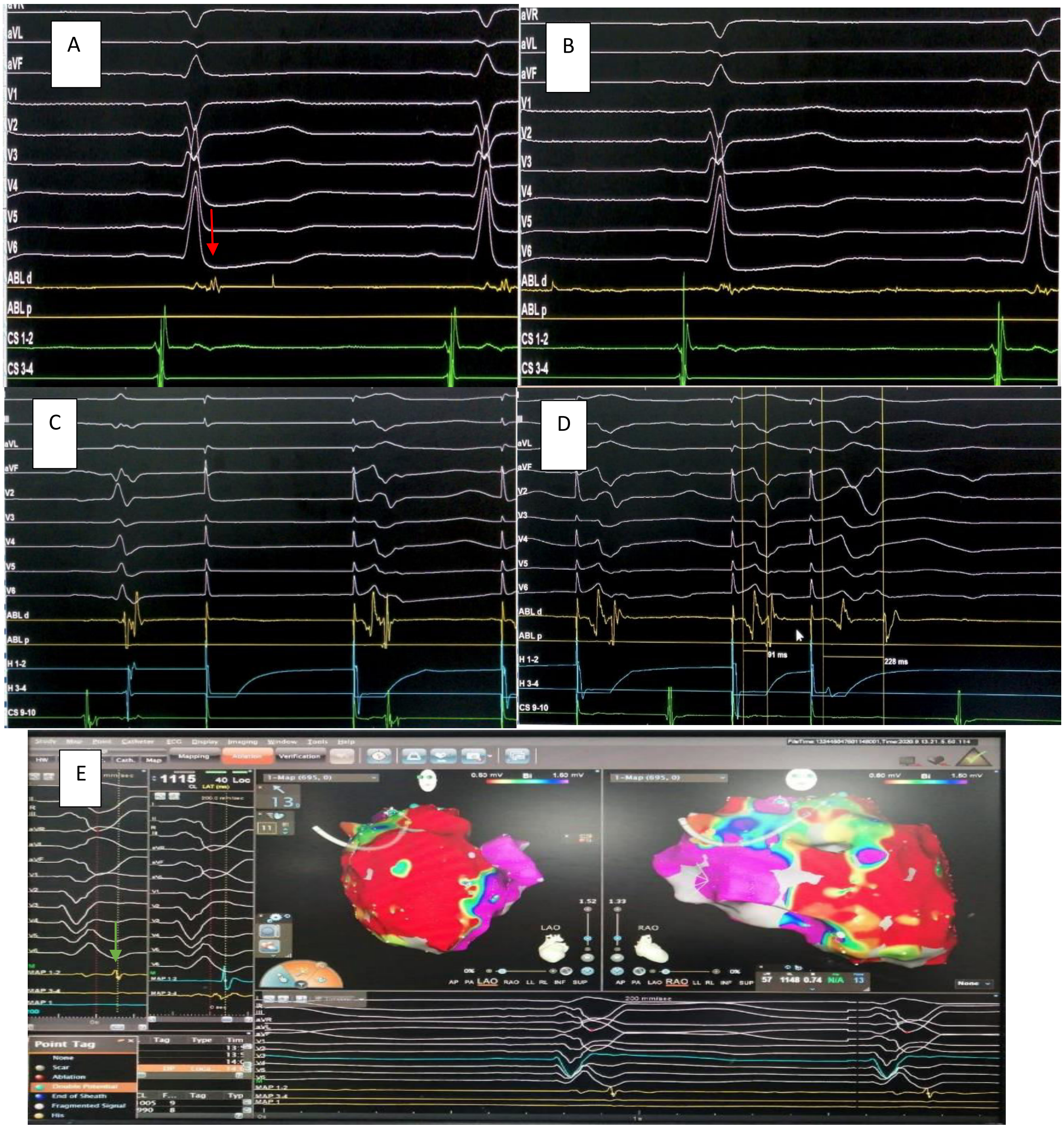


Figure (3): (A) Ablation catheter distal pole recording showing a far field ventricular electrogram (EGM) followed by a second potential (highlighted by a red arrow) in the first beat. (B) Upon delivery of RF current, the second component disappears (second beat). (C) The ablation catheter distal pole records a LAVA potential, that shows significant decrement upon delivering an RV extrastimulus as shown in (D). (E) An endocardial voltage map is shown in a patient with ischemic cardiomyopathy shows a large scar involving the apical segments, anterior wall, and septum. Recording at the mapping catheter shows a delayed potential (LAVA), green arrow.

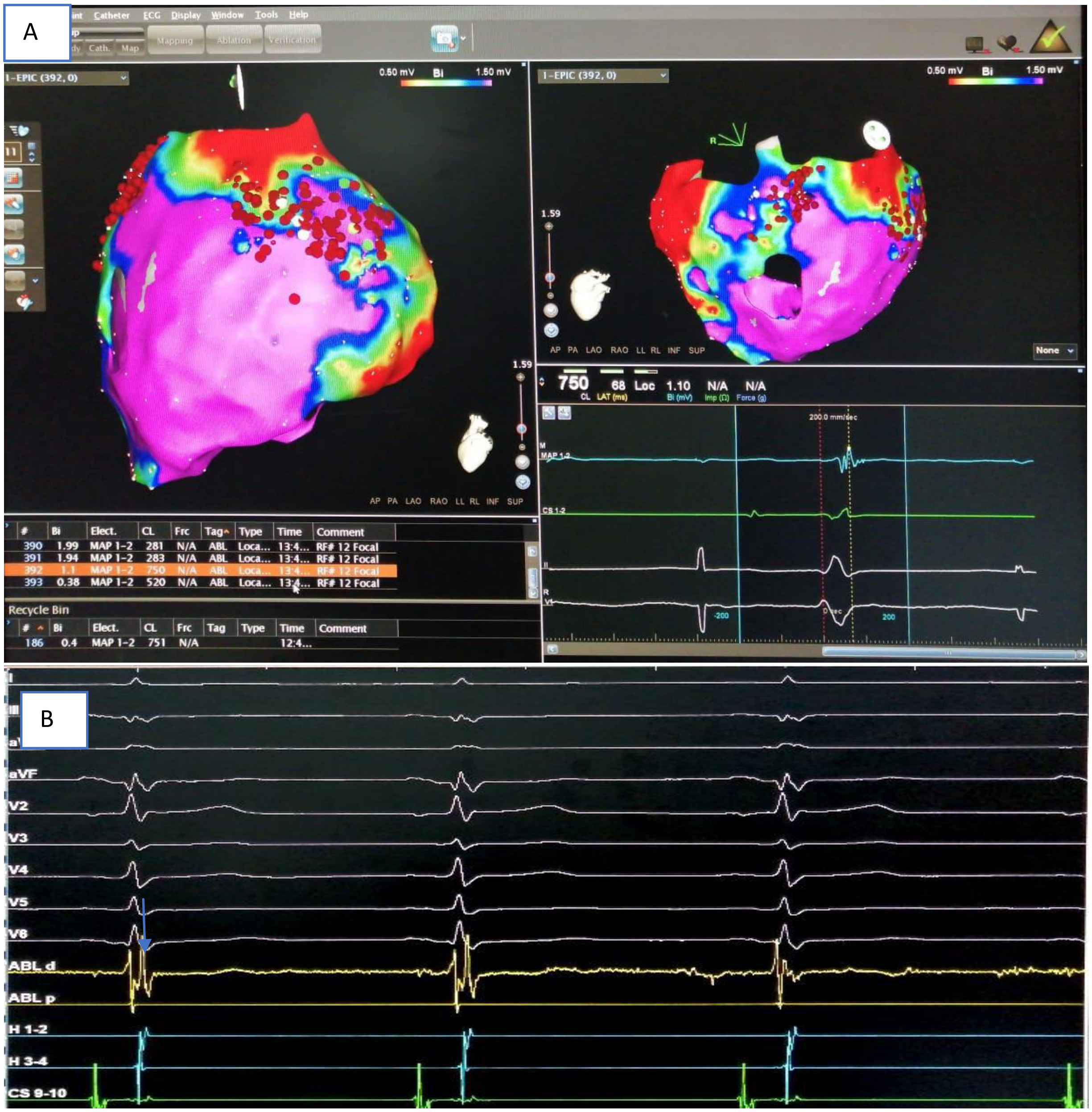


Figure (4) depicts an epicardial voltage map in a patent with dilated cardiomyopathy showing a low voltage area at the basal antero-lateral wall. The mapping catheter shows a sharp high frequency potential (highlighted by a blue arrow) inscribed at the terminal part of the far field ventricular electrogram (EGM) that represents a conducting channel entrance site; the target for ablation in the scar dechanneling technique. (B) An intracadraic electrogram (EGM) with the ablation catheter distal pole recording an electrogram with delayed component (E-DC) considered as the channel entrance site; a target for ablation that disappears with delivery of RF current.

Complications:

Overall incidence was 12.5% in the LAVA group, comparted to 21.4% in the dechanneling group. In the LAVA group, two patients developed VF requiring immediate defibrillarion. In the dechanneling group, one patient had acute pulmonary edema, another one had recurrent VT requiring multiple cardioversions and a third one sustained heart block due to ablation near the His region.

Follow up:

At a 3 month follow up period, nine patients (64%) of patients in the dechanneling group were free of any recurrence, compared to only seven patients (43%) in the LAVA elimination group. Yet, the recurrence in the form of VT storm was more in the dechanneling group (p value 0.017). However, this difference in recurrence rates has not been translated into a significant difference between the two groups in the need for ICD therapies or the number of shocks.

Table (3): 3-month follow up in the two groups.

	Technique		
	LAVA (N=16)	Dechannelling (N=14)	p-Value
3 month-recurrence, N (%)	9 (56.25%)	5 (35.71%)	0.261
VT storm recurrence at 3 months, N (%)	0 (0%)	3 (21.43%)	0.017
Follow up ICD Tx. N (%)	6 (37.5%)	5 (35.71%)	0.91
ICD Tx. Number Median (IQR)	16 (5 - 24)	5.5 (5 - 26)	0.686
Patients receiving shocks, N (%)	4 (25%)	4 (28.57%)	1.00
Number of shocks Median (IQR)	7.5 (2 - 16)	6 (3.5 - 9.5)	0.885
Causes and frequency of hospitalizations. N(%)			
VT	5 (31.25%)	4 (28.57%)	0.873
HF	1 (6.25%)	2 (14.29%)	
NYHA class, N (%)			0.794
I	2 (12.5%)	0 (0%)	
II	11 (68.75%)	12 (85.71%)	
III	2 (12.5%)	1 (7.14%)	
IV	1 (6.25%)	1 (7.14%)	
Amiodarone therapy (dosage). Number of patients (%)			
No	2 (12.5%)	0 (0%)	
200 (mg)	5 (31.25%)	4 (28.57%)	0.602
400 (mg)	9 (56.25%)	10 (71.43%)	
other AAD. Number (%)			
Mexilitine	2 (12.5%)	1 (7.14%)	0.599
Sotalol	2 (12.5%)	0 (0%)	
Mortality. N (%)	1 (6.25%)	1 (7.14%)	1.00

*Chi-Square test (X^2= Chi-Square test value). *Mann-Whitney test (U= Mann-Whitney test value).

AAD: antiarrhythmic drugs. HF: heart failure. ICD: implantable cardioverter defibrillator. ICD Tx= intra cardiac device therapy. LAVA: Local abnormal ventricular activity, N: number of patients. NYHA: New York heart Association. SD: standard deviation. VT: ventricular tachycardia.

At twelve months, the rate of recurrence of VT storm in the two groups was found to be 12.5% in the LAVA elimination group, compared to 21.4% in the dechanneling group. Yet, that difference did not reach statistical significance (table 4).

Table (4): 12 months follow up in the two groups.

	Technique		
	LAVA (n=15)	Dechannelling (n=13)	
	N (%) Median (IQR)	N (%) Median (IQR)	p-Value
12 month recurrence	8 (53.3%)	6 (46.2%)	0.715
VT storm recurrence at 12 months	2(13.3%)	2(15.4%)	1
Patients receiving ICD Tx. N(%)	8 (53.3%)	5 (38.46%)	0.45
Number of ICD Tx Median (IQR)	1.5 (0 - 28)	0 (0 - 6)	0.368
Patients receiving Shocks. N(%)	6 (40%)	4(30.77%)	0.69
Number of shocks received Median (IQR)	0 (0 - 7)	0 (0 - 3)	0.433
Causes and frequency of hospitalization			0.119
VT	5 (33.3%)	1 (7.7%)	
HF	1 (6.67%)	0 (0%)	
NYHA			0.001
1	2 (13.3%)	0 (0%)	
2	6 (40%)	13 (100%)	
3	4 (26.6%)	0 (0%)	
4	3 (20%)	0 (0%)	
Amiodarone dose			0.112
No	2 (13.3%)	1 (7.69%)	
200 mg	6 (40%)	11 (84.62%)	
400 mg	6 (40%)	1 (7.69%)	
600 mg	1 (6.7%)	0 (0%)	
Mortality. N(%)	4 (26.6%)	0 (0%)	0.098

*Mann-Whitney test of significance (U= Mann-Whitney test value).
HF: heart failure. ICD Tx= intra cardiac device therapy. LAVA: Local abnormal ventricular activity, N: number of patients. NYHA: New York heart Association. SD: standard deviation. VT: ventricular tachycardia.

The overall recurrence rates of VT in the two groups was 62.5% (ten patients) in the LAVA elimination group versus 50% (seven patients) in the dechanneling group, yet with a non-significant statistical difference (p value 0.491). As regards the overall rate of VT storm recurrence, it was 12.5% in the LAVA group, compared to 35% in the dechanneling group (p value 0.404), (figure 5).

The overall mortality rate in the LAVA group was 31.25% (five patients). Three patients died from VT recurrence, one died from advanced heart failure and finally, one who was not implanted an ICD had sudden unexplained death. In the dechanneling group, mortality rate was 7.14%; one patient who died from VT recurrence.

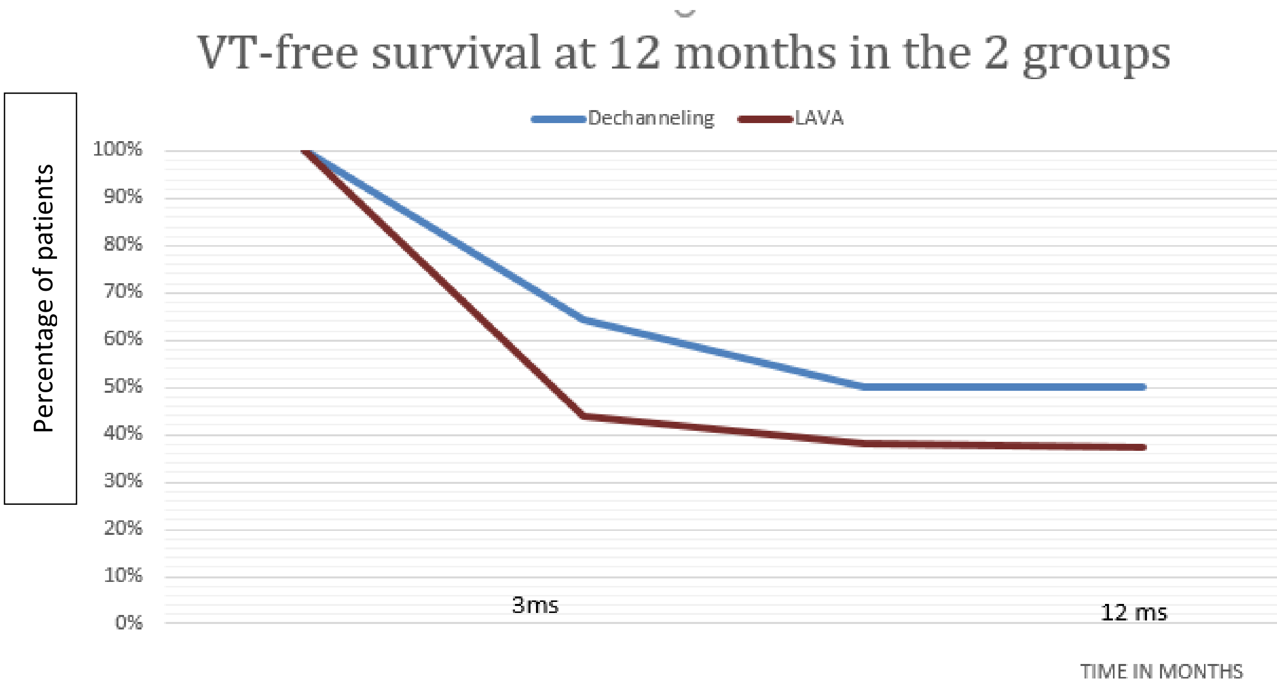


Figure (5): A survival analysis curve showing VT-free survival in the two groups up to 12 months

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Predictors of VT recurrence:

In evaluation of the predictors of VT recurrence in the whole treatment groups, it is worth mentioning that achievement of the study point (VT non-inducibility) was only marginally predictor of freedom from VT recurrence. (p value 0.052) (table 5). None of the other variables was a reliable predictor of VT recurrence.

Table (5): Univariate analysis showing predictors of VT recurrence in the whole study group.

	Recurrence		
	No	Yes	p-Value
Etiology of heart disease. N(%)			0.445
ICM	10 (52.63%)	9 (47.37%)	
DCM	3 (30%)	7 (70%)	
VHD surgery	0 (0%)	1 (100%)	
LVEF (%), mean ± SD	33.08 ± 7.93	32.41 ± 10.95	0.855
PAINESD score, N (%)	11.62 ± 3.78	11.12 ± 5.17	0.772
Access used. N (%)			
Endocardial	11 (52.38%)	10 (47.62%)	0.229

Endo and Epicardial	2 (22.22%)	7 (77.78%)	
Site of scar. N (%)			0.324
Anteroseptal & apical	6 (46.15%)	7 (53.85%)	
Inferolateral	5 (50%)	5 (50%)	
Perimitral & outflow	2 (66.67%)	1 (33.33%)	
Anteroseptal, apical & inferolateral	0 (0%)	4 (100%)	
RF Ablation points. N(%) Median (IQR)	49 (45 - 84)	80 (62 - 120)	0.103
Scar area % Mean ±SD	26.08 ± 12.85	29.65 ± 13.71	0.474
Contact force catheter used. (N. of patients)	1	3	0.613
Endpoint of VT non-inducibility. N (%)			
Achieved	13 (52%)	12 (48%)	0.052
Not achieved	0 (0%)	5 (100%)	

*Student t-test of significance (t= Student t-test value). *Mann-Whitney test of significance (U= Mann-Whitney test value).
DCM: dilated cardiomyopathy. Endo: Endocardial. ICM: ischemic cardiomyopathy. IQR: Inter quartile range. LAVA: Local abnormal ventricular activity. LVEF: Left ventricular ejection Fraction. N: number of patients. RF: radiofrequency. SD: standard deviation. VHD: valvular heart disease.

Discussion

This study aimed primarily at comparing the outcomes of radiofrequency (RF) catheter ablation for scar-related ventricular tachycardia (VT) using the scar dechanneling method as compared to local abnormal ventricular activities (LAVA) elimination. To our knowledge, there are studies describing each technique separately,[8,9,10,11,] but so far, no work has compared the two techniques head to head particularly in patients with VT storm.

Both techniques rely on mapping the VT substrate during sinus rhythm and targeting critical parts of the reentrant circuit that are crucial for maintaining the VT. This is particularly salient in such critical patients such as those presenting with VT storm.

The principle of LAVA ablation stems from the postulation that these abnormal electrograms; as defined by **Jais et al** [8], represent areas of slow conduction, due to a combination of fibrosis, myocyte disarray and connexin redistribution which creates a milieu for VT reentrant substrate. Abolition of these LAVA can disrupt the VT substrate rendering the VT non-inducible. However, we do not perform mapping during the VT, which means that not all these potentials are physiological components of the tachycardia circuit and that creates a problem of sampling bias. Hence, detailed mapping preferably with multielectrode mapping catheters is deemed necessary so as not to miss any active LAVA. This may have resulted in a relatively longer mean procedural time in our study in the LAVA group compared to the dechanneling group, albeit with a non-significant p value (0.142).

In addition, adopting this technique will result in ablation of many bystander areas. Counter-intuitively, this has not been reflected into a greater median number of ablation points in our study in the LAVA group compared to the dechanneling group. This can be attributed to lack of usage of contact force catheters in most of our cases in the dechanneling group which has driven us to deliver multiple RF applications to the target points to ensure complete abolition of the conducting channels (CCs) in the dechanneling group.

Acute procedural success was achievable in 87.5% in the LAVA elimination group, comparable to that achieved in the dechanneling group (78.57%). These figures are quite in line with acute success achieved in studies adopting these techniques.[8,10]

Regarding the follow up, it has been noted that the recurrence of VT storm at three months in the dechanneling group was more common than the LAVA ablation group (21.43% and 0% respectively, p value 0.017) despite the non-significant overall recurrence at three months between the two groups. If we get back to the principle behind each of these techniques, one can derive some explanation for that observation. The dechanneling method targets certain electrograms with earliest activation among a number of EGMs forming conducting channels i.e. it adopts a very focused approach for ablation compared to the LAVA group. This can come at the expense of leaving some local potentials that do not constitute active components of the circuit but may act as future components of newly developing substrates. In addition, from another perspective, substrates can have three-dimensional orientation, which means that we may not be able to demonstrate the whole corridor of conducting channels (CCs) or target the CC entrance of the VT substrate if we are mapping from e.g. the endocardial surface only. However, the overall recurrence both at 3 months and 12 months was comparable in the two groups. Further studies performed on a larger scale of patients, preferably randomized controlled trials (RCTs) will help confirm or rebut that finding. What is worth noting is that the higher rate of VT storm in the dechanneling group at three months has not been translated into a greater number of ICD therapies or shocks compared to the LAVA group. This can be attributed to the fact that patients with storm are expedititiously and aggressively managed such that the storm was successfully treated within 1-2 days.

The LAVA elimination group:

LAVA are mapped during either sinus rhythm or ventricular pacing by certain maneuvers to unveil the LAVA recording [9]. In our study, 50% of patients had non-ischemic cardiomyopathy (NICM), a figure obviously greater than that included in other studies adopting LAVA elimination. In addition, a multielectrode mapping catheter was used in only 12% of patients in our study, far less than in other studies using the LAVA elimination method [8,9]. Considering these two factors together, one can decode the difference in longer average procedural duration in our group (192 minutes) compared to other studies. Our procedural endpoint of VT non-inducibility could be achieved in 87.5%, somewhat greater than other studies of LAVA elimination. However, these studies considered complete LAVA elimination as their endpoint rather than non-inducibility.

As regards complication rate, concerning our study group, no procedure-related deaths occurred. However, two cases (12.5%) had ventricular fibrillation (VF) requiring immediate defibrillation. No cases had significant pericardial effusion or required surgical intervention. That was in line with other LAVA ablation studies.

The overall recurrence rate in our study group was 62.5%% at 12 months. This was quite greater than that found in other studies adopting the LAVA elimination method [8],[12]. At 12 months, mortality rate in our study was found to be five patients (31%), including 18% (3 patients) who developed recurrent VT. This figure is somewhat greater than reported in other studies [8],[12]. Yet, it is to be highlighted that we had a larger proportion of patients with VT storm and patients with non-ischemic cardiomyopathy which can gave obviously contributed to that outcome unevenness.

The Dechanneling method group:

In our study, we mapped on average 358.5 (205 - 757) points (median, IQR), delivered 74 (49 - 142) radiofrequency (RF) ablation lesions, with a final non-inducibility rate achieved in 78.6% of cases and procedural duration of 157.14 ± 38.11 minutes (mean ± SD). Compared to other studies, there was noticeably a lower number of mapped points and associated lower procedural time in our study cohort which can be attributed to the highly critical condition of a great percentage of our patients; 92.8% of them presented with a VT storm with an elevated PAINESD score. Added to that, we did not have mechanical circulatory support (namely ECMO) available. Consequently, we considered it prudent not to furtherly prolong the procedural time. Despite that, we could achieve the procedural endpoint of VT non-inducibility in almost the same proportion as other studies [10]. Another issue of note is that we did not use, in most cases, a multielectrode mapping catheter which explicates the relatively less number of mapped points in our patients.

If we come across the number of RF lesions delivered, we had a considerably greater number of lesions applied (median 74, IQR 49-142). This can be attributed to not using a contact force catheter in most of our procedures. Consequently, at many times we had to do multiple RF applications to ensure delivery of effective energy to our target sites and abolition of target electrograms. The procedure-related complication rate was in line with that reported in studies using the dechanneliing method [10,11].

On the other hand, the VT recurrence rate and the rate of appropriate ICD shocks in the our group (50% and 30% respectively) were quite more than that reported by Berruezo et al. (2015) who reported a recurrence rate of sustained VT/sudden cardiac death (SCD) and ICD shock rate at 21 months of 26.7% and 10% respectively.[10] However, a greater percentage of patients in our study group (92.5%) presented with a VT storm as opposed to only 27% in that studied by Berruezo et al. This might reflect the more extensive pathology as well as the more critical condition of our study group which may have hindered more extensive mapping and ablation protocols. Another study conducted by [11] on a cohort of 159 patients (80% had ischemic cardiomyopathy) using the dechanneling method reported a VT recurrence rate of 43.8% after a median follow up duration of 20 months in the arm that did not apply a cardiac MRI (CMR)-guided ablation. This figure approaches the recurrence rate in our study group. Mortality rate was 7% in our study group (dechanneling); comparable to that reported in other studies [10,11]

Predictors of recurrence:

As anticipated, failure to achieve VT non-inducibility at the end of the procedure was a significant significantly associated with future VT recurrence at the 12-month follow up period (RR 2.08, 95% CI 1.39-3.13), p value 0.043. Yet, achievement of VT non-inducibility was only marginally predictor of freedom from future VT recurrence (p value 0.052). [13] reported in their meta-analysis a statistically significant association between the achievement of VT non-inducibility as a procedural endpoint and freedom from VT recurrence at 12 months. Yet, other studies have not shown consistent results [14]. Thus, VT induction with programmed stimulation can be viewed as having a probabilistic rather than a deterministic value.

Conclusion

Scar dechanneling and LAVA elimination are two effective techniques for ablation of scar-related VT particularly in patients presenting with storm, who have represented a vast majority (90%) of our study group with a very good procedural success rate. They are comparable in terms of safety and efficacy. Although a significant overall recurrence rate has been reported, ablation has greatly contributed to the reduction in the number of shocks. Moreover, VT storm recurrence was significantly reduced in both groups. Yet, more advances in our understanding of the complex VT substrate and greater developments in the mapping and ablation will likely result in improved outcomes. VT non-inducibility is a sensible procedural end point but rather insufficient for accurate prediction of long-term freedom from VT recurrence.

Limitations

This is a single center observational study conducted on a relatively low number of patients. In addition, average follow up duration was 12 months. Consequently, larger multicenter studies, preferably randomized controlled trials are required to validate these results and permit their generalizability on a wide range of patients.

Abbreviations:

VT: ventricular tachycardia
LAVA: Local abnormal ventricular activity
ICD: Implantable cardioverter defibrillator
CC: conducting channels
E-DC: Electrograms with delayed components

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Ahmad G. Elewa: Concept of the study, Data acquisition, analysis & interpretation, Drafting article, Critical revision of article, Approval of submitted article, Statistics.
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Rania Samir: Concept of the study, Data interpretation, Critical revision of article, Approval of submitted article.
Said A. Khalid: Concept of the study, Data interpretation, Critical revision of article, Approval of submitted article.

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