Research Article

Physical Criteria of Radio Frequency Ablation in Patients with Cardiac Arrhythmia

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Abstract
Radiofrequency catheter ablation has become the standard care for management of various arrhythmias and, in fact, first-line therapy for many tachyarrhythmias. It entails creating scar tissue in the heart regions where abnormal impulses form or propagate to restore normal cardiac conduction. To identify and reduce the complications of radio frequency ablation. We enrolled 100 patients diagnosed with reentrant supraventricular tachycardias, including 78 with AVNRT, 14 with AVRT, and 8 with atrial tachycardia (AT), ranging in age from 10 to 75 years. This study was done in the Electrocardiography Department \ Baghdad Teaching Hospital from March 2025 to May 2025. There were significant differences among all physical parameters with arrhythmia types using one-way ANOVA test ($p<0.05$), except there was no significant difference between impedance drop and arrhythmia types ($p>0.05$), however an increases of mean for all arrhythmias types compared to all physical parameters. Radiofrequency lesion creation is determined by different parameters like power. During clinical radiofrequency ablation procedures, impedance significantly influences and varies considerably among patients. Impedance and power are clinically relevant parameters that should be considered during radiofrequency ablation.

INTRODUCTION

Cardiac arrhythmia is a heart rhythm disturbance caused by an electrical malfunction of a group of cells. The correct electrical activity of the cardiac cells controls the heartbeat and thus corrects blood circulation. There are two major kinds of cardiac arrhythmia: sinus node dysfunction and atrioventricular block types[1].

Radiofrequency cardiac ablation (RFCA) is a minimally invasive technique used to eliminate some cardiac arrhythmias and consists of delivering an radiofrequency current through a percutaneous catheter whose tip has a metal electrode which is placed over the tissue responsible for the arrhythmia[2].

Radiofrequency ablation is performed by applying alternating current at ˜500 kHz from the tip electrode of an ablation catheter through a resistive volume (myocardial tissue and blood) to a patch located on the patient's surface. The current that passes through the resistive tissue generates heat that raises the tissue temperature. Once this temperature exceeds ˜55°C, the cells undergo a process of irreversible thermal-induced necrosis[3]. A higher temperature at the source leads to a greater depth of heating[4]. there is a direct correlation between the power and temperature, whereby an increase in power to increased tissue heating, resulting in the formation of larger ablation lesions[5]. the biophysics of radiofrequency lesion formation is known to be the result of a complex interplay of many factors, namely radiofrequency delivery time, catheter contact force (CF), power delivered, and tissue impedance[6]. Echocardiography has an important role to follow up patient post catheter ablation during electrophysiological study, is considered nowadays the primary focus of patient management with supraventricular tachycardia (SVT)[7]. and has gradually expanded the role it plays in the treatment of different types of arrhythmias. due to the interatrial septum's oblique position and the left atrium's (LA) long and narrow appendage, the left atrium's (LA) has a complex morphology that may make echocardiographic assessment challenging[8]. transseptal puncture (TSP) has been increasingly and commonly required over the past two decades of the left atrium (LA) catheterization, in order to perform ablation of different types of arrhythmias[9].

Importance of Lesion Effectiveness

Effective lesions are characterized by their ability to permanently block the aberrant electrical circuits that cause arrhythmias[10]. Several key factors influence the formation of effective lesions during radiofrequency ablation:

Power Delivery: The power delivered is directly related to the heat generated and, consequently, the size and depth of the lesion in the tissue. Adequate power is necessary to achieve the desired temperature within the tissue, which typically ranges between 50 and 100 °C (5).

Duration of Energy Application: The length of time Radiofrequency energy is applied also plays a crucial role in lesion formation. Longer application times generally lead to larger lesions[11].

Tissue Impedance: Tissue impedance, which reflects the resistance of the tissue to the flow of electrical current, can impact the distribution of Radiofrequency energy. Lower impedance typically allows for more efficient energy delivery[3,12]

Contact Force: The force with which the ablation catheter contacts the tissue is another critical determinant of lesion effectiveness. Insufficient contact force may result in inadequate energy transfer, leading to superficial lesions[5].

Electrode Size and Geometry: The size and geometry of the ablation electrode influence the spatial distribution of the Radiofrequency energy[11].

Aim of Study: To identify and reduce the complications of radio frequency ablation.

Patients and Methods: This study was done in the Electrocardiography Department \ Baghdad Teaching Hospital from March 2025 to June 2025. The study protocol was approved by the local Ethics Committee, and all subjects gave informed consent for participation in the study.

Study Design: This study was conducted as a prospective study, clinical observational study to evaluate the impact of Radiofrequency parameters on lesion formation during ablation procedures for tachyarrhythmias.

Patient Sampling: 100 consecutive Patients ranges between 10 and 75 years old with tachyarrhythmias, including supraventricular tachycardia undergoing radiofrequency ablation excluding atrial fibrillation and atrial flutter. Antiarrhythmic drugs were discontinued for a minimum of 5 days prior to the procedure.

Ablation Procedure: Each procedure was performed under local anesthesia with 2% Xylocaine venous. Using standard catheterization techniques, an ablation catheter was introduced into the heart chamber of interest. Three types of catheters were used in each study to take signal from three areas in the heart (Atrium, Ventricular and Ablation). After advancing this catheter in the heart with fluoroscopy guide connected cable were used for each catheter to reach conventional EP system with 64 channels for display the intracardiac signal on the screen.

And then the setting was done with two screen paper from intracardiac and surface ECG[11]. In all cases the reference patches of the systems were placed in the patient in a conventional manner. RF energy was applied at predetermined settings, with variations in power, temperature, and duration to assess lesion formation.

RF Parameter Monitoring: The parameters examined included RF power (in watts), temperature (in degrees Celsius), duration of energy delivery (in seconds), and tissue impedance (in ohms). Each parameter setting was carefully monitored and adjusted during the procedure to evaluate the effects on lesion formation.

Diagnosing the Case: An electrophysiology study is conducted to detect the type of arrhythmia. Then, catheter ablation is conducted.

Lesion Assessment: Parameters are watched during the operation to determine good lesion. In some cases, ablation is repeated more than once to ensure the arrhythmia stops. In such cases, parameters are averaged for accurate reading. The sign of successful ablation was the appearance of accelerated junctional rhythms. And ablation stops after 20 seconds if there are no junctional rhythms. After ablation presence of anterograde slow pathway with or without atrioventricular node echo beat not consider as failure of ablation. So, the end point of ablation Non inducibility of the arrhythmia and it is accepted endpoint as good indicator with successful ablation. ref.

Statistical Analysis: Data collected from each procedure were analyzed to identify the optimal Radiofrequency parameters for effective lesion formation. Statistical analysis was used as a statistical package for social science (SPSS) ver.28 to determine correlations between parameter settings and procedural outcomes, with a focus on safety and effectiveness in reducing arrhythmia recurrence. Descriptive frequencies like mean, standard deviation and standard error mean were used. To test all the parameters for RF study one-way ANOVA test.

RESULTS AND DISCUSSIONS

Out of the 100 patients, the mean, standard deviation value and standard error mean of weight, height and BMI of all patients. The standard error mean values of weight, height and BMI were nearby the same for all that implies the variability of sample means in a sampling distribution of means, were shown in Table 1.

Out of the 100 patients, the mean, standard deviation value and standard error mean of physical parameters of the studied group like power (w), temperature (0c), time (sec), impedance drops (ohms), and procedure duration (min) of all patients, were shown in Table 2.

Note: - AVRT: Atrioventricular nodal reentry tachycardia, AVRT: Atrioventricular reentry tachycardia and AT: Atrial tachycardia.

One-way ANOVA test using for analyzing the effect of the arrhythmias types results according to all physical parameters. When P-Value >0.05 that indicates no significant differences between arrhythmia types and power was found, while (P-Value < 0.05) that represents the significant differences between arrhythmia types and power was found. There was a highly significant difference of arrhythmias among all physical parameters except arrhythmia types with impendence drop according to (P-value=0.852), as displayed in Table3.

The study showed that patients with arrhythmia take different physical parameters of the studied group like power (w), temperature (0c), time (sec), impedance drops (ohms), and procedure duration (min). The role of heart specialist physician is well-known firmly in recognition of arrhythmia types.

This study showed that the temperature, time and ablation physical parameters had a high statistical significance of arrhythmia patients. This study came up with results similar to the results of the study of(14) which showed that influenced temperature was more significant.

The study describes a new approach to treating arrhythmias such as AVNRT, AVRT, and AT, where radio frequency energy is delivered via a catheter to target. the slow pathway of the AV node in AVNR, accessory pathways in AVRT, or ectopic foci in the atria in AT. There were three arrhythmia types like AVNRT, AVRT and AT. AVRT is a kind of paroxysmal supraventricular tachycardia, which causes the existence of a re-entry circuit within or neighboring to the AV node(15). AVNRT where the re-entry circuit is within the AV node and the ventricle plays no part in maintaining the arrhythmia. Atrial tachycardia, where the re-entry circuit does not involve any part of the AV junction e.g. atrial flutter, ectopic atrial tachycardia[16,17]. typical atrioventricular nodal reentrant tachycardia (AVNRT) is the most common paroxysmal supraventricular tachycardia among adults(18).

Adequate tissue temperature is needed for successful radiofrequency catheter ablation of arrhythmia. The results of this study suggest that adequate tissue temperature is related to a 10 to 15ohm decrease in measured impedance.

The usual range of baseline impedance observed during human studies has been reported to be in a range between 100 and 120O a lower impedance leads to increased output current (I) due to the inverse relationship P = I2 × Z. The more current that is

Table 1: The mean standard deviation and standard error mean demographic parameters

Parameters	Body Mass Index	Weight	Height
Mean	83.7600	83.76	165.54
Std. Error of Mean	1.92758	1.928	1.308
Std. Deviation	19.27584	19.276	13.079

Table 2: The frequency distribution of physical parameters

Parameter	Power (w)	Temp. (0c)	Ablation Time (sec)	Impedance drop (ohms)	Procedure duration (min)
Mean	36.347	47.9855	78.116	-14.365	70.11
Std. Error of Mean	.6805	.32000	4.9708	.4296	3.884
Std. Deviation	6.8053	3.19995	49.7084	4.2958	38.844

Table 3: The relative frequency of arrhythmia types according to physical parameters

Physical parameters		N	Mean	Std. Deviation	Std. Error	P-value
Temp	AVNRT	78	48.2596	3.16155	.35797	0.046
	AVRT	14	46.0500	3.38611	.90498	
	AT	8	48.7000	2.15936	.76345	
	Total	100	47.9855	3.19995	.32000	
Power	AVNRT	78	35.688	6.4912	.7350	0.000
	AVRT	14	42.857	5.7091	1.5258	
	AT	8	31.375	3.6228	1.2809	
	Total	100	36.347	6.8053	.6805	
Ablation time	AVNRT	78	70.162	39.7318	4.4987	0.007
	AVRT	14	111.571	76.5654	20.4630	
	AT	8	97.125	57.7716	20.4253	
	Total	100	78.116	49.7084	4.9708	
Impedance drop	AVNRT	78	-14.224	4.3653	.4943	0.814
	AVRT	14	-15.000	3.3512	.8957	
	AT	8	-14.625	5.4232	1.9174	
	Total	100	-14.365	4.2958	.4296	
Procedure duration	AVNRT	78	59.82	22.512	2.549	0.000
	AVRT	14	88.93	54.814	14.650	
	AT	8	137.50	55.742	19.708	
	Total	100	70.11	38.844	3.884	

distributed at the ablation site[19], That result supports the idea that local tissue heating leading to lower impedance drives the overall impedance drop, and higher baseline local impedance implies better tissue contact and more tissue heating resulting in larger lesions[20,21]. the more heating that is produced and the larger the lesion that is formed[22]. Furthermore, these data demonstrate that arrhythmia types occur with approximately 78%, 14% and 8% of applications associated with at least a 31watt increase in power and that in human beings a highly significant and clinically relevant correlation exists between arrhythmia types and power (P=0.000). Power generated by the radio frequency generator and represented by watts (W)[3]. These data propose that the use of power monitoring can be considered as another parameter for temperature and that ablation time to perform a 60 to 140 sec be used to attain adequate tissue temperature without coagulum formation[11].

CONCLUSION

Increasing the power and temperature in RF to achieve effective lesions for many types of arrhythmias, will generate a larger ablation lesion, and are similar in ablation time created using catheter ablation. Furthermore, ablation strategies showed by impedance drop observing during ablation applications have been presented to perform high levels of success for ablation of atrial insertion. Power increase during ablation may thus be utilized as an additional endpoint beyond critical to conduction block, to enhance the durability of ablation lesions.

Note: The authors declared that there is no conflict of interest.

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