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Electrophysiology study in patients with supraventricular tachycardia

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Abstract

Background: Supraventricular tachycardias are paroxysmal tachyarrhythmias which require atrial or atrioventricular nodal tissue or both for their initiation and maintenance & they are often recurrent, occasionally persistent, and a frequent cause of visits to emergency rooms and primary care physicians. **Objectives:** The aim of the study is to evaluate patients presented with a surface electrocardiographic diagnosis of supraventricular tachycardia & assess their demographics, electrophysiologic findings & radiofrequency ablation results, and complications throughout their course of hospitalization. **Patients and Methods:** This is a retrospective study; we have had analysed 331 patients admitted at Al-Nasiriya Cardiac Center between the 4$^{th\ of}$ January 2020 and to 8th of October 2021 with the clinical & electrocardiographic diagnosis of supraventricular tachycardia regarding their surface electrocardiography at baseline & during the arrhythmia, their demographic features, Electrophysiologic study, radiofrequency ablation & its outcome & complications. **Results:** At the electrophysiology study, the mean cycle length was 35.54 msec; about 86% had decremental Ventriculoatrial conduction. In 77.3% of the cases, arrhythmia was inducible & in 22.7%, it was non-inducible. In those with non-inducible arrhythmia, Dual Atrioventricular physiology occurred in 22% & echo beats (as a sign of Dual Atrioventricular physiology) occurred in (0.9%). Two hundred twelve (64%) of patients had atrioventricular nodal re-entrant tachycardia, 37 (11.2%) had atrioventricular re-entrant tachycardia; others were consisting of atrial fibrillation, atrial flutter, atrial tachycardia, & other supraventricular tachycardias. Radiofrequency ablation was done successfully in 220 patients & in 7 cases; arrhythmia is still inducible despite ablation. Recurrence occurred in only 3 (1.32%) of those who underwent successful ablation. The study with or without ablation was uneventful in 315 patients (95.2%). With radiofrequency ablation, 12 patients got transient atrioventricular blocks & 4 patients developed complete heart blocks and ended with a permanent pacemaker. **Conclusion:** In this thesis, 331 patients underwent an Electrophysiology study & Radiofrequency ablation. There is a female preponderance with male to female ratio of 1:1.7. Most common presentation was palpitation. At an electrophysiology study, Ventriculoatrial conduction was mainly decremental, with arrhythmia inducibility in around 77.3% of patients; the majority being atrioventricular nodal re-entrant tachycardia. The study was effective & uneventful in the majority of the cases.

Keywords:

Introduction

Supraventricular tachycardia refers to paroxysmal tachyarrhythmias, which require atrial or atrioventricular nodal tissue, or both, for their initiation and maintenance. Supraventricular tachycardias are often recurrent, occasionally persistent, and a frequent cause of visits to emergency rooms and primary care physicians.

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Patients with symptomatic tachycardias require immediate medical attention [1]. Although it is commonly believed that a precise diagnosis of tachycardia is necessary before therapy is initiated, immediate treatment can usually be tailored to the characteristics of the ventricular response. SVT.s are not usually associated with structural heart disease, although there are exceptions (e.g., the presence of accessory pathways associated with hypertrophic cardiomyopathy or Epstein's anomaly and atrial tachycardias in patients with congenital or acquired heart disease). Re-entry arrhythmias are usually induced by premature atrial or ventricular ectopic beats, and precipitating factors such as excessive intake of caffeine, alcohol, or recreational drugs and hyperthyroidism can increase the risk of recurrence [2]. By focusing on the ventricular response, one can assign the seven clinically relevant SVT.s to diagnostic and therapeutic groups based on the rapidity of onset, the heart rate, and the regularity of the tachycardia. Sinus tachycardia [3], by far the most common SVT, is not a pathologic arrhythmia (with the rare exception of inappropriate sinus tachycardia) but rather is an appropriate cardiac response to a physiological event. Sinus tachycardia is gradual in onset and recession [4,5]. The heart rate is regular and classically does not exceed 220 beats per minute, minus the patient's age. Atrial fibrillation is the most common pathologic supraventricular tachycardia. Risk factors for AF include older age, male sex, hypertension, and underlying cardiac disease [6]. AF is caused by multiple electrical wavelets appearing in the atria simultaneously, resembling the waves that would be produced if one dropped several pebbles in a bucket of water at the same time. With all cases of AF, the ventricular response is irregular, and the ventricular rate ranges from 60 to 220 beats per minute, depending largely on the patient's age, whether there is any underlying AVN disease, and whether the patient has received any drugs that affect the AVN. Atrioventricular nodal re-entrant tachycardia is caused by a re-entrant loop that involves the AVN and the atrial tissue [7]. It constitutes about 60% of the tachyarrhythmias caused by re-entrant loops where the AVN has two conduits; one conducts rapidly and the other slowly [8]. The slower pathway, which lies parallel to the tricuspid valve, allows for a re-entrant loop as the electrical impulse meanders through the slow pathway, exiting the AVN in a retrograde manner (i.e., backward from the node to the atrium) and in an anterograde manner (i.e., forward, or from the node to the ventricle) at the same time. Atrioventricular reciprocating tachycardia is caused by cardiac musculature that bypasses the normal insulation afforded by the tricuspid and mitral valves between the atria and the ventricles [9]. These bypass tracts may conduct in an anterograde direction only, in a retrograde direction only, or in both directions. A delta wave, an initial slurring of the QRS complex, is present on the surface ECG in most cases of anterograde bypass tracts and indicates partial depolarization of the ventricular tissue resulting from rapid conduction of the electrical impulse from the atrium to the ventricle over the bypass tract [10]. Atrial tachycardia is a focal tachycardia that may be a result of a micro-re-entrant circuit or an automatic focus. There are two unique characteristics of Arts, they may occur in repetitive short bursts, and they are frequently characterized by a warm-up phenomenon in which the atrial rate increases slightly over the first 5 to 10 seconds before stabilizing. Surface ECGs show a P wave preceding each QRS complex, although, at rapid heart rates, the P wave may be obscured by the T wave. Multifocal atrial tachycardia occurs because of multiple atrial premature beats in an atrium poisoned by hypoxia, increased atrial pressure, and, perhaps most important, theophylline [11]. Common symptoms of supraventricular tachycardia include palpitations, anxiety, light-headedness, chest pain, pounding in the neck and chest, and dyspnea. Syncope is uncommon, but some patients have serious psychological distress [12]. Polyuria can occur in prolonged episodes, mainly owing to the release of atrial natriuretic peptide. The initial differential diagnosis of SVT should focus on the ventricular response, not on atrial depolarization, as observed on the ECG [13]. The 1st step is to determine whether the QRS complex is narrow or wide [14]. Then regularity should be assessed. Regularity is defined as the variation of less than 10% in beat-to-beat timing, but most regular tachycardias vary by less than 5% [15]. This paper aims to assess patients with supraventricular tachycardia, Demographic data, Electrophysiologic findings, Radiofrequency Ablation results, and Complications.

Patients and Methods

After obtaining informed consent, all patients presented with symptomatic SVT & documented by surface ECG were admitted at least overnight & underwent EP study at –Nasiriya cardiac Centre- Cath. Lab from 4th January 2020 to 8th October 2021. All antiarrhythmic drugs were discontinued at least five or half times of the respective drugs before the study except Amiodarone, which was withdrawn six weeks before the procedure.

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Patients with manifest WPW at surface ECG & those presented with tachyarrhythmias other than SVT (AF, AFL, AT) at surface ECG were excluded. Case sheets of all the patients were studied & checked carefully regarding the history, clinical examination findings, blood investigations, surface ECG at rest & during episodes of SVT & operative notes of EP study & RF ablation. Any complications were recorded & documented & the status of the patients at hospital discharge was documented. Usually, patients are overnight fasting under local anesthesia, both femoral areas are chosen after sterilization using the seldinger technique, and four intravenous sheaths are inserted in both femoral veins (two for each vein, usually 6 F with 1 line 7 F for the ablation catheter).

Three quadripolar EP catheters (Josephson carve, 5 or 6 F size) were inserted for the right atrium, right ventricle & His recording for intra-cardiac EGM recording & programmed stimulation. Basic intervals, including R-R interval, PR interval, AH, HV interval, QRS & QT duration recorded first while a patient was in sinus rhythm. Programmed ventricular stimulation to assess ventriculoatrial conduction is then performed (whether VA conduction is decremental or not), and programmed atrial stimulation is then done to induce SVT. Usually, a train of 10 beats, starting at 600 msec reduced according to the pre-stated protocol to 270 msec. If this failed to induce the arrhythmia, adding of S2 to the above protocol was performed. If an arrhythmia is still non-inducible, a dose of intravenous Atropine, 0.6-1.2 mg, was given. If no inducible arrhythmia is seen, the whole above protocol is repeated with ventricular stimulation. If still no arrhythmia is induced, documentation of dual AV physiology (AH jump of 50 msec with reduction of 10 msec in CL of arrhythmia stimulation or occurring of more than one echo beat) have been done. If no dual AV physiology is documented, the study is considered negative. If SVT is induced, a detailed study of the arrhythmia is done, including measurement of arrhythmia CL & VA duration. Atrial flutter or fibrillation is usually diagnosed easily at EP lab. During SVT, ventricular pacing at a cycle length of 10-30 msec shorter than the SVT CL was done for a short period and then stopped. Atrial tachycardia proved if the response after cessation of ventricular pacing is VAAV & excluded if the response is VAV. Three measurements were used to differentiate AVRT from AVNRT:

1- Delta VA
Difference of VA during SVT & VA during ventricular pacing
If > 85 msec in favour of AVNRT
If < 85 msec in favour of AVRT.

2- Post-pacing interval (PPI) minus tachycardia cycle length (TCL)
If > 115 msec in favour of AVNRT
If < 115 msec in favour of AVRT

3- Atrial entrainment

If atrial CL at ventricular pacing entrained at 1st or 2nd pacing beats, it is AVRT; if not, it is AVNRT. If contradicting results occurred, atrial entrainment results were used for the final diagnosis. RF ablation is usually done according to the final diagnosis & according to the standard protocol using radiofrequency ablation. If the final diagnosis is AVNRT, ablation using Jazaery s approach is usually performed. If the final diagnosis is AVRT, ablation is usually targeted to the earliest atrial activity during arrhythmia. If the final diagnosis is manifest WPW, the ablation is done according to the site of the bypass tract. For statistical analysis, a statistical package for social sciences (SPSS) version 21 software developed by IBM was used; continuous variables like age & QRS width were expressed as mean ± standard deviation, while categorical variables like gender were expressed in percentages.

Results

Three hundred thirty-one (331) patients were included in the study; the mean age was 42.47 years, ranging from 5 to 78 years. Sixty-four percent (64%) were females. Four patients were hypothyroid; however, no patients have had the hyperthyroid disease. **(Table 1)**

Most common presenting symptoms were palpitation, SOB & chest pain; syncope was the initial presentation in only 3.9% of patients. **(Table 2)**

Evaluation of ECG during sinus rhythm showed that 42.9% of the patients had normal ECG with ST-T changes present in 47.7%. **(Table 3)**

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During SVT, the surface ECG showed that the average rate was about 191 bpm & most patients had narrow complex SVT, and only five patients have had wide QRS. There were no visible P waves preceding QRS complexes, 7 cases had pseudo-S waves in the inferior leads & 5 cases have had R′ in V1. **(Table 4)**
During the EP study, the mean CL of SVT was 325.54 msec, and about 86% had decremental VA conduction. In 83.98% of the cases, arrhythmia was inducible & in 16%, it was non-inducible. In those with non-inducible SVT (77 cases), Dual AV physiology occurred in 20.77% & echo beats (as a sign of Dual AV physiology) occurred in (3.8%) of the patients. **(Table 5)**
Two hundred twelve (64%) of patients were AVNRT, 37(11.2%) AVRT, and others were consisting of AF, AFL, AT, & other SVTs. **(Table 6)**
RF ablation was done successfully in 220 patients & in 7 cases; arrhythmia is still inducible despite ablation. Recurrence occurred in only 3 (1.36%) of those who underwent successful ablation. **(Table 7)**
The EP study with or without ablation was uneventful (no complications) in 315 patients (95.2%).In those with RF ablation, 12 patients developed transient AV block & 4 patients developed CHB that necessitated permanent pacemaker. Of note, no vascular complications occurred & no mortality has been reported. **(Table 8)**

Table 1: Demographic distribution of patients with SVT

Variable	**Frequency (%)**
Mean age ± SD (years)	42.47±14.032
Gender: Male Female	 119 (36%) 212 (64%)
DM no. (%)	47 (14.2%)
HT no. (%)	68 (20.2%)
IHD no. (%)	22 (6.6%)
Smoking: no. (%) Nonsmoker Smoker Ex-smoker	 295 (89.1%) 13 (3.9%) 23 (6.9%)
Bronchial asthma no. (%)	8 (2.4%)
Hypothyroidism no. (%)	4 (1.2%)

Table 2: Presentation of patients with SVT

Variable	**Frequency (%)**
Palpitation	328 (99.1%)
Chest pain	84 (25.4%)
Shortness of breath	75 (22.7%)
Dizziness	16 (4.8%)
Syncope	13 (3.9%)
Sweating	13 (3.9%)
Nausea and vomiting	11 (3.3%)

Table 3: Baseline ECG

Variable	**Frequency (%)**
Normal ECG	142 (42.9%)
Axis: Normal LAD RAD	 300 (90.6%) 26 (7.9%) 5 (1.5%)

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RBBB: Complete Partial	 9 (2.7%) 29 (8.8%)
LBBB:	5 (1.5%)
ST-T changes	158 (47.7%)

Table 4: ECG during SVT

Variable	Minimum	Maximum	mean± ST
Rate (BPM)	126	300	191.07±40.23
QRS width (msec)	40	150	65.96±20.83
Wide QRS (msec) (5 patients out of 134)	120	150	132±10.95

Table 5: EP study for patients with SVT

variable	Frequency (%)			
VA conduction Decremental Non-Decremental	 285 (86.1%) 46 (13.9%)			
Arrhythmia inducibility Inducible Non-Inducible	 278 (83.98%) 53 (16%)			
Dual AV physiology Positive DAVP Negative DAVP	 16 (20.77%) 58 (75.32%)			
Echo beats	3 (3.8%)			
Negative study	53 (16.3%)			
	No.	minimum	maximum	Mean ± SD
CL	248	200	522	325.54±52.094
VA	248	5	276	92.02±59.944

Table 6: **Final diagnosis of arrhythmia**

Variable	Frequency (%)
AVNRT	212 (64%)
AVRT	37 (11.2%)
AT	9 (2.7%)
AFL	7 (2.1%)
AF	1 (0.3%)
Ill sustained SVT	5 (1.5%)
Combined atrial arrhythmia	4 (1.2%)
ST	2 (0.6%)
PVC	1 (0.3%)
Negative study	53 (16%)

Table 7: **Ablation: Successfulness & Recurrence**

variable	Frequency (%)
Ablation is done (in 227 cases out of 331)	227 (68.58%)

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Successful unsuccessful	220 (96.9%) 7 (3.08%)
Ablation not done	104 (31.4%)
Recurrence (out of 220 successful ablations) No recurrence recurrence	 217 (98.63%) 3 (1.36%)

Table 8: **Complications of EP study**

Variable	Frequency (%)
No complication (out of 331 cases EPS)	315 (95.2%)
Complete heart block with spontaneous recovery (out of 227 ablations)	12 (5.2%)
Complete heart block ended with a permanent pacemaker (out of 227 ablations)	4 (1.7%)
Vascular site complications	0 (0%)
mortality	0 (0%)

Discussion

Out of 331 patients candidated for EPS & RFA, 212 (64%) were females, and 119 (36%) were males; this is compatible with the results of many studies done for EPS & arrhythmias like that of (Zahid Aslam Awan et al.) & (Tadros R et al.) as SVTs are more common in females. Mean age was 42.47 years, ranging from 5 to 78 years, as EPS & RFA can be applied for both children & adults [16,17]. Regarding associated co-morbidities, 47 (14.2%) were diabetics, 68 (20.2%) had hypertension, 22 (6.6%) with IHD, 8 (2.4%) were Asthmatic, & only 8 (2.4%) were hypothyroid with no thyrotoxicosis cases. Smoking profile revealed that the majority of patients were non-smokers (295 (89.1%)), only 13 (3.9%) were currently smoking while 23 (6.9%) have had gave up smoking. (Table 1). Most common presenting symptoms were palpitation, SOB & chest pain. Syncope was the initial presentation in only 3.9% of patients. These are going with the results occurred with Tikkanen I, Metsarinne K, and Fyhrquist F. 2. Twenty-two cases (6.6%) have been DC shocked for haemodynamic unstability (from history written in their case sheets) (Table 2). During the EP study, the mean CL of SVT was 325.54 msec; about 86% had decremental VA conduction, and others, 46 (13.9) have non-decremental VA conduction [18]. In 83.98% of the cases, arrhythmia was inducible & in 16%, it was non-inducible. In those with non-inducible SVT (77 cases), Dual AV physiology occurred in 20.77% & echo beats (as a sign of Dual AV physiology) occurred in (3.8%) of the patients. This is a reasonable finding as most of the patients were defined to have AVNRT, which is usually associated with decremental VA conduction, as shown by Wellens HJ. & Strickberger SA. Arrhythmia was induced in about 278 (83.98%) of the cases versus 53 (16%) with non-inducible arrhythmia, a result nearly the same as that mentioned by Alpay Çeliker et al. (Table 5). Regarding the final diagnosis of the arrhythmias, two hundred twelve (64%) of patients have had AVNRT, and 37 (11.2%) had AVRT, results in nearly the same as shown by Wellens HJ. & Strickberger SA [18]. Other types of SVT, like AF, AFL, & others, are compatible with that of (Zahid Aslam Awan, Mohammad Irfan, Bakhtawar Shah, Lubna Noor, Sher Bahadar Khan, and Faisal Amin). Majority of patients with AVNRT were females, which is documented by many authors like Tadros R et al. & Zahid Aslam Awan et al. Males are less than females in AVRT; a finding does not match with that recorded in common articles & journals; usually, males are affected more than females, this is probably due to the exclusion criteria which we have had used in selecting the cases for EPS & RFA, as we excluded individuals with surface ECG of WPW syndrome & most cases of WPW syndrome having AVRT (Table 6). Considering RF ablation, it has been performed collectively for about 227 patients. Of which 212 cases with AVNRT, except for 5 cases, all are successful, i.e., 97.64% successful, with only 2.35% not successful. Out of 37 cases labeled to have AVRT

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as the underlying mechanism of arrhythmia, only 11 candidates have undergone RAF (they were not performing it for this diagnosis during the first three years of starting EPS & RFA). For whom it was performed, 9 (81.81%) procedures were successful, and 2 (18.18%) were unsuccessful. These results are very close to those announced by Hugh Calkins, VK Ajit Kumar & Johnson Francis. There are four ablations done for other types of SVTs, 2 for AFL, 1 for ectopic beats & 1 for a patient with combined inappropriate sinus tachycardia & ectopic beats; all of them were successful. Findings like Junctional ectopic, prolongation of the PR interval, transient AV block & inability to induce the arrhythmia with electrical & mechanical electrophysiological stimulation & using of medications are regarded as signs of successful ablations [19]. During ablation, one patient developed AF & another one got AFL, for which the procedure was aborted due to the instability of the patients, findings exactly seen with Alpay Çeliker et al. Recurrence after successful ablation occurred with 3 cases (1.36%); which is within the reported range universally as by Hugh Calkins et al. (Table7). The EP study with or without ablation was uneventful (no complications) in 315 patients (95.2%). In those with RF ablation [20,21], 12 patients developed transient AV block & 4 patients developed CHB that necessitated permanent pacemaker. Of note, no vascular complications occurred & no mortality has been recorded. These results are compatible with those of Schilling R.J, Jackman WM & Haissaguerre M. (Table 8)

Conclusion

1. SVTs are most commonly due to AVNRT or AVRT.
2. EPS is a useful means for the diagnosis & determination of the different types & mechanisms of SVTs.
3. RFA is a safe & effective method of treatment for SVT & should be considered as the first line of therapy if EPS services are available. We recommend supplying cardiac centers with EP study facilities.

1- Enhancing this approach for the management of different types of arrhythmias.
2- Sending all the patients suffering from tachyarrhythmias for centers capable of doing EP study & RFA to cure them & avoid adverse effects of chronic drug therapy.

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