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ORIGINAL ARTICLE

Characteristics of Patients Undergoing Electrophysiologic Procedures in a Tertiary Hospital in Saudi Arabia

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Abstract

Introduction: **The electrophysiology field has progressed rapidly over the last 2 decades. No study has examined the characteristics of patients and types of electrophysiology procedures performed in the Kingdom of Saudi Arabia. This is important given our distinctly different demographic composition and health system. As such, we sought to describe the characteristics of consecutive patients presenting for electrophysiology procedures in our tertiary care hospital.**

Methods: **Data was collected from the electrophysiology database at King Khalid University Hospital for procedures performed between April 2016 and November 2022. Patients' characteristics were retrieved from the electronic medical record. Procedures were categorized into supraventricular tachycardia, premature ventricular contraction and "complex ablations", which included atrial fibrillation and scar-mediated ventricular tachycardia ablation. If no abnormality was found, the procedure was labeled as "normal EP study". Multivariate regression analysis was performed to assess predictors of atrioventricular nodal reentry tachycardia among patients presenting with undifferentiated supraventricular tachycardia.**

Results: **A total of 459 patients were included in the study. The mean age was 42.06 years (±14.89 years), and 256 (55.77 %) were females. The most common procedure was supraventricular tachycardia (n = 289/459, 63.24 %), and only 5 % had complex ablations. The most common type of supraventricular tachycardia ablated was found to be atrioventricular nodal reentry tachycardia (n = 157/289, 54 %). Multivariate logistic regression revealed female sex and age to be independently associated with atrioventricular nodal reentry tachycardia (OR = 2.27 95 % CI [1.40−3.67]) for female sex and (OR = 1.02 95 % CI [1.01−1.04]) for every increase in age by 1-year**

Conclusion: **We reported a younger average age than other countries and less complex ablations. In addition, we reported 2 independent predictors of atrioventricular nodal reentry tachycardia in patients presenting with undifferentiated supraventricular tachycardia. Larger studies including multiple centers should be performed to confirm our findings.**

Keywords: Electrophysiology procedures, Supraventricular tachycardia, Saudi Arabia, Arrhythmia, Atrial fibrillation

1. Introduction

The field of electrophysiology (EP) has experienced rapid progress in recent years. Limited data is available pertaining to the EP procedures performed in Saudi Arabia and the characteristics of patients undergoing these procedures. The demographic composition of Saudi Arabia significantly diverges from that of Western nations, potentially influencing the gamut of EP procedures conducted. Indeed, the average age of the population in Saudi Arabia is 10−15 years younger than

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western countries [1]. In additions, some procedures such as Atrial Fibrillation (AF) have been shown to be performed less frequently than western countries but reasons for that are not clear [2]. By understanding the patients' characteristics and type of procedures performed, one can have a better use of resources which should help improve the EP service in Saudi Arabia.

Thus, we sought to describe the characteristics of EP procedures in a large tertiary center in Riyadh, Saudi Arabia.

2. Methods

This was a retrospective observational quantitative cross-sectional study. Data from King Khalid University Hospital (KKUH) were collected from April 2016 to November 2022. KKUH is a teaching hospital in Riyadh, Saudi Arabia. It has over 1200 beds and provides a wide range of medical services. It is affiliated with King Saud University and is the home to a dedicated electrophysiology lab that is comprised of 3 consultants. All consultants are north-american trained who perform all types of EP procedures. The use of 3D mapping system was left to the discretion of the treating team.

2.1. Data source

Data was collected from the EP database at KKUH, which included type of the procedure, date, and basic demographics. Other variables such as comorbidities and medications were retrieved from the electronic medical records. Procedures were categorized into supraventricular tachycardia (SVT), premature ventricular contraction (PVC) and complex ablations. If no abnormality was found, the procedure was labeled as "normal electrophysiology study (EPS)". We considered atrioventricular nodal reentry tachycardia (AVNRT), atrioventricular reentry tachycardia (AVRT), Wolff-Parkinson-White (WPW) syndrome, atrial tachycardia (AT) and atrial flutter (AFL) as SVT. WPW was diagnosed if patients had manifest pre-excitation and AVRT was diagnosed when accessory pathways were concealed. Complex ablations included atrial fibrillation (AF) and scar-mediated ventricular tachycardia (VT) ablation.

2.2. Ethical considerations

The Institutional Review Board (IRB) of King Saud University College of Medicine approved the present study. The requirement for informed consent was waived because of the anonymous nature of the data.

Abbreviations

EP	Electrophysiology
AF	Atrial Fibrillation
KKUH	King Khalid University Hospital
EPS	Electrophysiology study
SVT	Supraventricular tachycardia
PVC	Premature ventricular contraction
AVNRT	Atrioventricular nodal reentry tachycardia
AVRT	Atrioventricular reentry tachycardia
WPW	Wolff-Parkinson-White syndrome
AT	Atrial tachycardia
AFL	Atrial flutter
VT	Ventricular tachycardia
DM	Diabetes mellitus
HTN	Hypertension
KSA	Kingdom of Saudi Arabia
BMI	Body mass index
AV blocker	Atrioventricular blocker
CCB	Calcium channel blocker
BB	Beta blocker
ECG	Electrocardiogram

2.3. Statistical analysis

Continuous variables were presented as mean (± standard deviation) whereas categorical variables were expressed as numbers (percentages). Chi Square test or Fisher's exact test were used to compare categorical variables and Student's t-test or ANOVA were used to compare continuous variables, as appropriate. We used multivariate regression modeling to assess predictors of AVNRT. For the purpose of this, SVTs were divided into AVNRT versus (AVRT/AT). This was done given its clinical utility as these 3 tachycardias are often hard to distinguish before performing the EPS (i.e. all can present with narrow-complex regular tachycardia with non-diagnostic "P" waves), and predicting AVNRT beforehand can help plan the procedure when it comes to choosing appropriate equipments (e.g. use of 3D mapping system) as the variability in ablation sites, the longer time and higher dose of fluoroscopy in AVRT and AT render 3D mapping more favorable [3,4].

3. Results

3.1. Overall population

A total of 459 patients were included in the study. The mean age was 42.06 years (±14.89 years), and 256 (55.77 %) were females. The mean body mass

index was 29.75 kg/m2 (±7.76 kg/m2). The most common comorbidities were diabetes mellitus (DM) (n = 100, 21.79 %) followed by hypertension (HTN) (n = 96, 20.92 %). The most common procedure was SVT (n = 289, 63.24 %), and 12.91 % had normal EPS. The majority (61.05 %) of patients were not on any medication, while 35.89 % were taking AV blockers, and only 3.06 % were on Anti-arrhythmic medications. The use of 3-D mapping was observed in 33.7 % of procedures (155/459). Table 1 summarizes the characteristics of the overall population.

The most common site was septal for pathways, right-sided for ATs and right ventricular outflow tract for PVCs. All AF ablation procedures included pulmonary vein isolation and 2/20 (10 %) had an additional posterior wall isolation. Figure 1 depicts anatomic sites of ablation for accessory pathways (AVRT and WPW), ATs and PVCs. Acute success was observed in 94 % (95 % CI: 85 %–99 %) of AVRT/WPW procedures, 88 % (95 % CI: 65 %–99 %) of ATs and 88 % (95 % CI: 75 %–95 %) of PVCs. Reasons for acute failure in AVRT/WPW were as follow: one patient had pericardial effusion necessitating abortion of the procedure, one had a parahisian's pathway and one had 2 accessory pathways where one was ablated in the first procedure and the second in a stagged procedure. Of note, one pediatric patient was excluded from the analysis and had multiple right-sided pathways that were not successfully ablated.

Table 1. Characteristics of the overall cohort.

Variables	N = 459
Age (y)	42.061 (±14.886)
Sex (female)	256 (55.77 %)
BMI (kg/m2)	29.749 (±7.759)
Diabetes mellitus	100 (21.79 %)
Hypertension	96 (20.92 %)
Dyslipidemia	55 (11.98 %)
Myocardial infarction	14 (3.05 %)
Stroke	7 (1.53 %)
Smoking	48 (10.46 %)
Medications:	
No medications	279 (61.05 %)
AV blocker (CCB or BB)	164 (35.89 %)
Anti arrhythmic (Amiodarone or flecainide)	14 (3.06 %)
Normal EP study	59 (12.91 %)
SVT	289 (63.24 %)
PVC's	87 (19.04 %)
Complex ablation	22 (4.81 %)
3D mapping	155/459 (33.7 %)

Continuous variables are presented as mean (± standard deviation) whereas categorical variables are expressed as numbers (percentages). Complex ablation: includes atrial fibrillation (AF) and scar-mediated ventricular tachycardia (VT) ablation. AV blocker: atrioventricular blocker, BMI: body mass index, BB: beta blocker, CCB: calcium channel blocker, PVC: premature ventricular contraction, SVT: supraventricular tachycardia.

3.2. Comparisons between different procedures

Table 2 compares characteristics of patients stratified by their procedures. Age distribution was significantly different among different procedures where the average age in patients with normal EPS was 36.7 (±15.86) and for complex ablations was 50 (±12.75). Similarly, sex was significantly different with a predominant male sex in patients who underwent complex ablations (16/22, 72.3 %) as compared with female predominance in patients with SVT (175/289, 60.6 %). AV blockers were commonly used in all diagnoses whereas antiarrhythmics were mainly used in patients with PVCs and complex ablations. Diabetes mellitus was prevalent in all diagnoses (21.5%–25.3 % range) whereas history of myocardial infarction was mainly seen in patients with complex ablations (3/22,13.6 %).

3.3. Comparisons between different types of SVT

A total of 289 had SVT. The most common type was found to be AVNRT (n = 157) (54.33 %) followed by WPW (n = 61) (21.11 %). Table 3 compares characteristics of all types of SVTs. Atrial flutter patients had distinctly different characteristics than other types of SVT with older age and higher prevalence of comorbidities such as DM and HTN. Sex distribution was significantly different among different types of SVTs with female predominance in AVNRT (109/157, 69.4 %) and male predominance on WPW (37/61, 60.7 %). Similarly, age distribution was significantly different with younger age in accessory pathway-related SVT (WPW and AVRT) (range: 30.9–32.6 years), oldest in AFL group (59 years) and in between for AVNRT and AT (44.2 years, 45.5 years, respectively). Antiarrhythmics were mainly used in accessory pathway-related SVT (AVRT and WPW) whereas AVBs were used commonly used in all types of SVTs (range: 11.5%–64.1 %).

3.4. Predictors of AVNRT

Table 4 compares AVNRT to other types of SVT (excluding AFL). Patients had comparable characteristics except for an older age for AVNRT (44.2 vs 38.8, p = 0.0023) and higher prevalence of females (69.4 % vs 55 %, p = 0.0008). Multivariate logistic regression showed that these 2 factors remained independently associated with AVNRT (OR = 2.27

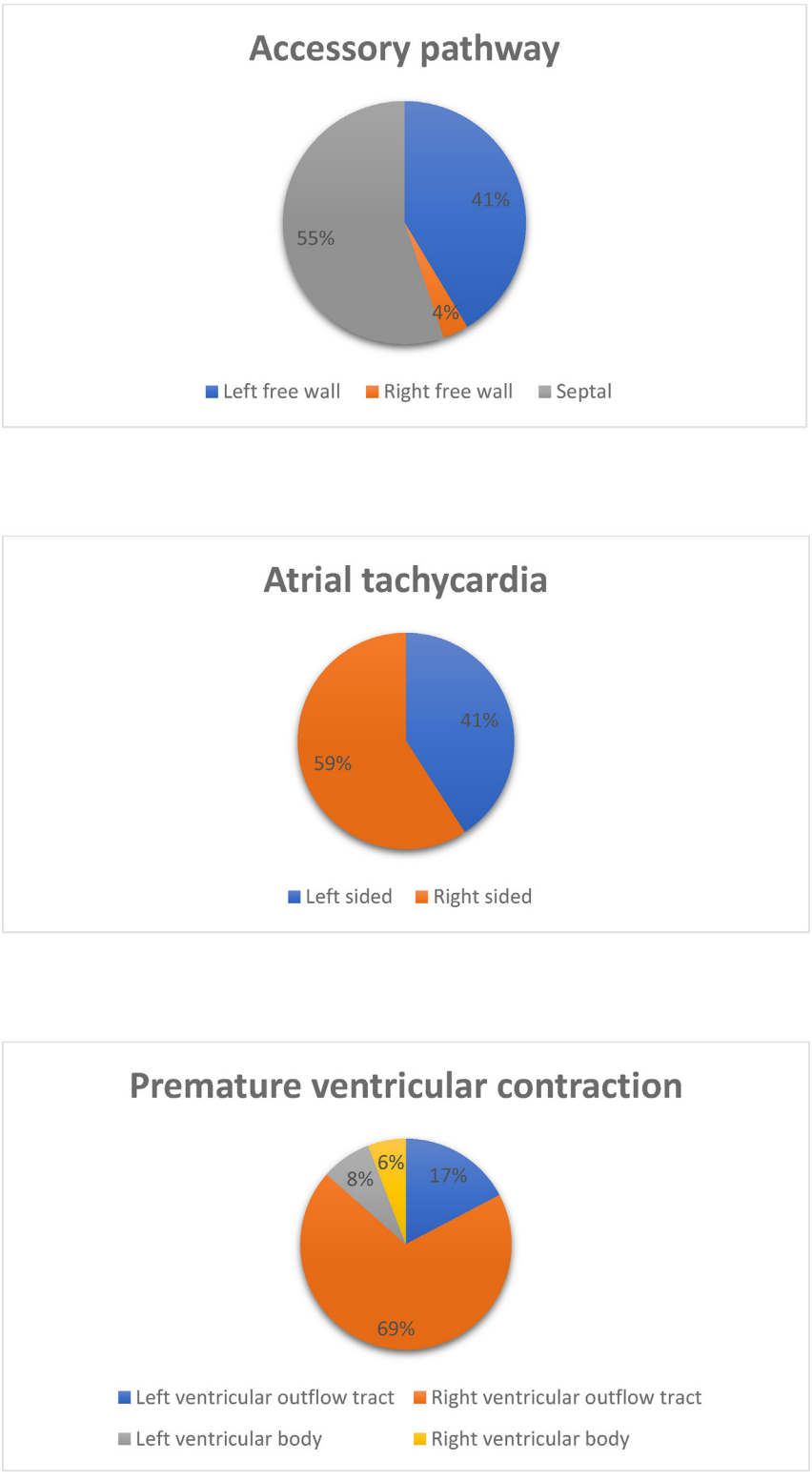

Fig. 1. Successful ablation sites for atrial tachycardia, accessory pathway and premature ventricular contractions.

Table 2. Comparisons between different diagnoses.

Variables	SVT (n = 289)	Normal EPS (n = 59)	PVC (n = 87)	Complex ablation (n = 22)	P-value
Age (y)	41.75 (±15.05)	36.73 (±15.86)	44.85 (±12.90)	50 (±12.75)	<0.001
Sex (female)	175 (60.55 %)	34 (57.63 %)	41 (47.13 %)	6 (27.27 %)	0.006
BMI (kg/m2)	29.42 (±7.72)	28.92 (±7.78)	31.73 (±8.11)	29.09 (±5.82)	0.076
Diabetes mellitus	62 (21.45 %)	10 (16.95 %)	22 (25.29 %)	5 (22.73 %)	0.69
Hypertension	58 (20.07 %)	9 (15.25 %)	20 (22.99 %)	9 (40.91)	0.079
Dyslipidemia	35 (12.11 %)	4 (6.78 %)	12 (13.79 %)	4 (18.18 %)	0.461
Myocardial infarction	6 (2.08 %)	1 (1.69 %)	4 (4.60 %)	3 (13.64 %)	0.016
Stroke	4 (1.38 %)	1 (1.69 %)	2 (2.30 %)	0 (0 %)	0.865
Smoking	28 (9.69 %)	5 (8.47 %)	11 (12.64 %)	3 (13.64 %)	0.774
Medications:					
No medications	183 (63.76 %)	39 (66.10 %)	48 (55.17 %)	8 (36.36 %)	0.024
AV blocker (CCB or BB)	97 (33.80 %)	19 (32.20 %)	36 (41.38 %)	11 (50.00 %)	
Anti arrhythmic (Amiodarone or flecainide)	7 (2.44 %)	1 (1.69 %)	3 (13.64 %)	3 (13.64 %)	
3D Mapping	46/289 (15.9 %)	0 (0 %)	87/87 (100 %)	22/22 (100 %)	

Continuous variables are presented as mean (± standard deviation) whereas categorical variables are expressed as numbers (percentages). Complex ablation: includes atrial fibrillation (AF) and scar-mediated ventricular tachycardia (VT) ablation. AV blocker: atrioventricular blocker, BMI: body mass index, BB: beta blocker, CCB: calcium channel blocker, PVC: premature ventricular contraction, SVT: supraventricular tachycardia.

Table 3. Comparisons between different types of SVT.

Variables	AVNRT (n = 157)	AVRT (n = 16)	AT (n = 39)	WPW (n = 61)	AFL (n = 16)	P-value
Age (y)	44.203 (+13.866)	32.625 (+16.082)	45.538 (+14.192)	30.868 (+10.643)	59 (+11.667)	<0.0001
Sex (female)	109 (69.43 %)	9 (56.25 %)	26 (66.67 %)	24 (39.34 %)	7 (43.75 %)	0.0007
BMI (kg/m^2)	30.001 (+7.566)	27.855 (+11.788)	29.155 (+6.819)	27.985 (+7.767)	31.490 (+5.875)	0.3223
Diabetes mellitus	38 (24.20 %)	2 (12.50 %)	10 (25.64 %)	2 (3.28 %)	10 (62.50 %)	<0.0001
Hypertension	31 (19.75 %)	1 (6.25 %)	14 (35.90 %)	3 (4.92 %)	9 (56.25 %)	<0.0001
Dyslipidemia	15 (9.55 %)	1 (6.25 %)	8 (20.51 %)	4 (6.56 %)	7 (43.75 %)	0.0003
Myocardial infarction	2 (1.27 %)	0 (0.00 %)	0 (0.00 %)	0 (0.00 %)	4 (25.00 %)	<0.0001
Stroke	1 (0.64 %)	1 (6.25 %)	0 (0.00 %)	1 (1.64 %)	1 (6.25 %)	0.1486
Smoking	15 (9.55 %)	0 (0.00 %)	3 (7.69 %)	5 (8.20 %)	5 (31.25 %)	0.0321
Medications:						
No medications	101 (64.33 %)	11 (68.75 %)	14 (35.90 %)	51 (83.61 %)	6 (42.86 %)	<0.0001
AV blocker (CCB or BB)	54 (34.39 %)	3 (18.75 %)	25 (64.10 %)	7 (11.48 %)	8 (57.14 %)	
Anti arrhythmic (Amiodarone or flecainide)	2 (1.27 %)	2 (12.50 %)	0 (0.00 %)	3 (4.92 %)	0 (0.00 %)	

Continuous variables are presented as mean (+ standard deviation) whereas categorical variables are expressed as numbers (percentages). AV blocker: atrioventricular blocker, AVNRT: Atrioventricular nodal reentry tachycardia, AVRT: Atrioventricular reentry tachycardia AT: Atrial tachycardia, AFL: Atrial flutter, BMI: body mass index, BB: beta blocker, CCB: calcium channel blocker, PVC: premature ventricular contraction, SVT: supraventricular tachycardia, WPW: Wolf-Parkinson-White.

Table 4. Predictors of AVNRT.

Variables	AVNRT (n = 157)	AVRT/AT (n = 132)	P-value	Univariate OR	Multivariate OR
Age (y)	44.203 (±13.866)	38.825 (±15.900)	0.0023	1.02 (1.01–1.04)	1.02 (1.01–1.04)
Sex (female)	109 (69.43 %)	66 (55 %)	0.0008	2.27 (1.4–3.68)	2.13 (1.31–3.48)
BMI (kg/m2)	30.001 (±7.566)	28.731 (±7.866)	0.112		
Diabetes mellitus	38 (24.20 %)	24 (18.18 %)	0.2141		
Hypertension	31 (19.75 %)	27 (20.45 %)	0.8808		
Dyslipidemia	15 (9.55 %)	20 (15.15 %)	0.1463		
Myocardial infarction	2 (1.27 %)	4 (3.03 %)	0.2969		
Stroke	1 (0.64 %)	3 (2.27 %)	0.2358		
Smoking	15 (9.55 %)	13 (9.85 %)	0.9328		
Medications:					
No medications	101 (64.33 %)	82 (63.08 %)	0.371		
AV blocker (CCB or BB)	54 (34.39 %)	43 (33.08 %)			
Anti arrhythmic (Amiodarone or flecainide)	2 (1.27 %)	5 (3.85 %)			

Continuous variables are presented as mean (± standard deviation) whereas categorical variables are expressed as numbers (percentages). AVRT: atrioventricular reentrant tachycardia. AT: atrial tachycardia. AV blocker: atrioventricular blocker, BMI: body mass index, BB: beta blocker, CCB: calcium channel blocker, OR: odds ratio.

95 % CI [1.40–3.67]) for female sex and (OR = 1.02 95 % CI [1.01–1.04]) for every increase in age by 1-year. Choosing an age cutoff of 65 year-old was found to be specific but not sensitive for AVNRT (specificity 96 % and sensitivity 7 %).

4. Discussion

Our study examined the characteristics of patients undergoing EP procedures in a tertiary hospital in Saudi Arabia and reported distinctly different characteristics than other countries. Namely, our patients have a younger average age and certain EP procedures such as AF ablation are performed less frequently. We also identified 2 independent predictors of AVNRT using baseline clinical factors.

Our average age of patients presenting for EP procedures is 20–25 years younger than other countries (Table 5) [5–7]. This is not surprising given the overall younger average age of the Saudi population as compared to other countries. However, one would expect less comorbidities for this young cohort of patients, which is not the case. Indeed, the prevalence of DM for example is similar or higher than other countries. This is consistent with epidemiologic studies done in Saudi Arabia [8]. Almost all studies of different cardiovascular diseases in Saudi Arabia performed over the last 2 decades showed similar younger average age and higher prevalence of comorbidities [9–11].

Another important finding from our study is the significantly lower numbers of AF ablations. While AF ablation has become the most common procedure performed in most EP labs worldwide, it was seldom performed in our study. One potential explanation is the younger average age of the population. AF is known to be associated with aging and it is possible that less patients with AF are seen in KSA in general. In addition, it is possible that the awareness about AF ablation is lacking in practicing cardiologists in Saudi given the relative recency of the procedure. However, PVC ablation, which is also a relatively recent procedure is frequently performed suggesting that this factor is likely not the primary reason for this finding. Moreover, AFL ablation, an old procedure, is seldom performed in our population as compared with western countries. For example, AFL was found to be the second most common procedure performed in Europe as compared to being performed in <5 % of our population [12]. AFL patients share similar characteristics to AF patients which support our hypothesis that differences in population characteristics rather than availability and awareness of these procedures are the main reasons for the discrepancies in procedure types.

In our study, we identified that being female and of older age are predictive factors for AVNRT among patients with SVT (excluding AFL). It is essential to emphasize that the individual clinical utility of these factors is limited due to their low predictive value when used in isolation. Our finding of female predominance in AVNRT is in line with previous work [13]. As highlighted by Suenari et al., women not only have a higher incidence of both typical and atypical AVNRT but also tend to present symptoms and receive diagnoses at earlier ages than men [13]. A plausible explanation for this sex disparity could lie in hormonal dynamics. Studies have shown a relationship between hormonal shifts and AVNRT incidence, suggesting that decreased estrogen and increased progesterone levels during the luteal phase of the menstrual cycle elevate the risk, while pregnancy, marked by hormonal surges, correlates with reduced AVNRT cases [14].

While It is well-documented that patients with AVRT often present at younger ages compared to those with AVNRT, it was not clear if that will be true in our population given our younger average age and the bimodal age distribution of AVNRT [15,16]. However, we showed that age is a significant predictor even in our population. This age difference might be influenced by the presence of manifest pre-excitation (WPW) which often lead to early detection even in asymptomatic patients due to their distinct ECG patterns. In light of these insights, clinicians planning interventions for patients with documented SVT should consider both age and sex as valuable indicators to anticipate AVNRT.

Our study is the first to describe the characteristics of patients presenting for EP procedures in the Saudi population. However, it has limitations. First, it was a single-center study. Other centers might

Table 5. Comparison between different countries.

Variables	Age	Sex	Comorbidities	Most common procedure
Saudi	42.061	Male (44.3 %)	Diabetes mellitus (21.8 %)	AVNRT (34.35 %)
US [7]	65	Male (65.2 %)	Diabetes mellitus (19.8 %)	AF ablation (57.6 %)
Germany [6]	55.8	Male (54.4 %)	Diabetes mellitus (6.3 %)	AF ablation (38.1 %)
Japan [5]	65.8	Male (66.6 %)	NA	AF ablation (74.8 %)

Continuous variables are presented as mean (+ standard deviation) whereas categorical variables are expressed as numbers (percentages). AF: atrial fibrillation, AVNRT: atrioventricular nodal re-entry tachycardia, NA: not applicable.

have different findings depending on the population they serve, the background and training of their electrophysiologists and the facilities available to them. In addition, the short course of the study makes it difficult to check for changes over the years. EP is a fast-growing specialty, and one might find different characteristics if the study is repeated even in the near future. It is important to note that our time-dependent sensitivity analysis did not reveal any major differences between the years, however, numbers were relatively small in each year. Last, useful data such as indications for procedures and whether patients were admitted through the emergency department or elective were not collected and might have provided more insight about the characteristics of our patient population.

5. Conclusion

We described the characteristics of patients presenting for EP procedures. We reported a younger average age than other countries and less AF and AFL ablations. In addition, we reported 2 independent predictors of AVNRT in patients presenting with undifferentiated SVT. Larger studies including multiple centers should be performed to confirm our findings.

Author contribution

Conception and design of Study: WAA. Literature review: AAA, MKA, IA, MAA, AS, ASA, FGA, MFA, SQ, WAA. Acquisition of data: WAA. Analysis and interpretation of data: WAA. Research investigation and analysis: AAA, MKA, IA, MAA, AS, ASA, FGA, MFA, SQ, WAA. Data collection: AAA, MKA, IA, MAA, AS, ASA, FGA, MFA, SQ, WAA. Drafting of manuscript: AAA, MKA, IA, MAA, AS, ASA, FGA, MFA, SQ, WAA. Revising and editing the manuscript critically for important intellectual contents: AAA, MKA, IA, MAA, AS, ASA, FGA, MFA, SQ, WAA. Data preparation and presentation: AAA, MKA, IA, MAA, AS, ASA, FGA, MFA, SQ, WAA. Supervision of the research: WAA. Research coordination and management: AAA, WAA.

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Conflicts of interest

None declared.

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