ORIGINAL ARTICLE

Feasibility and safety of interventional electrophysiology and catheter ablation in the South African public sector: Challenges and opportunities for comprehensive cardiac electrophysiology in South Africa

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Abstract

Aims: The spectrum and outcomes of catheter ablation procedures performed in South Africa are unknown, and therefore, the feasibility of interventional electro-physiology in the South African public sector is undetermined.

Methods and Results: This study was a retrospective review of all patients that underwent invasive electrophysiology procedures and catheter ablation at Groote Schuur Hospital (GSH) and the University of Cape Town Private Academic Hospital (UCTPAH) between 01 January 2013 and 31 December 2020.

One thousand one hundred eighty-six invasive electrophysiology procedures were performed during the study period. Of these were 1102 catheter ablation procedures. There were 76 redo catheter ablation procedures, predominantly for atrial fibrillation (AF), which accounted for 39% (30/76) of the repeat procedures. There were only 0.8% (9/1102) catheter ablation related complications which were mostly access related. Atrial fibrillation accounted for most of the ablation procedures, 28.9% (318/1102); these were mainly performed at UCTPAH than at GSH, 300 vs 18 p < .0001. Cavotricuspid isthmus (CTI) dependent atrial flutter ablation was the second most commonly performed catheter ablation procedure, accounting for 21.6% (238/1102) of the catheter ablation procedures. More CTI dependent atrial flutter ablations were performed at GSH than a UCTPAH, 156 vs 82 p < .0001. The overall success rate of catheter ablation was 92%.

Conclusion: A broad spectrum of catheter ablation procedures was performed with a high success rate and limited complications, thus demonstrating the feasibility of safe cardiac electrophysiology and catheter ablation in the South African public sector.

KEYWORDS

complications and outcomes, interventional electrophysiology, resource constraint settings, south African public sector

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1 | BACKGROUND

Interventional electrophysiology is a rapidly growing section of cardiology. The field of cardiac electrophysiology has progressed from being only investigational, studying the mechanisms of arrhythmias and antiarrhythmics drugs, to being interventional and curative for many cardiac arrhythmias. Today, the success rates of catheter ablation for some forms of supraventricular tachycardias are higher than 95% in experienced institutions.¹ Further, catheter ablation for recurrent arrhythmias is cost-effective, improves the quality of life, and reduces mortality in selected patient groups.^{2,3} However, the translation and uptake of newer technologies and interventions in low-income countries have been slow and limited to a few centres, mainly in the private sector.⁴ For example, data from the first Latin American catheter ablation registry, including data from 120 centres located in Argentina, Bolivia, Brazil, Chile, Colombia, Cuba, El Salvador, Guatemala, Mexico, Peru, Dominican Republic, Uruguay and Venezuela, indicated that 63% of centres were in the Private sector; and only 25% were public sector centres.⁵ South Africa has 55.7 million people and a 34.9% unemployment rate.⁶ In 2018, only 16.4% of South Africans were on medical aid or medical insurance; these numbers are expected to worsen due to the ongoing COVID 19 pandemic.⁷ Further, there are critical racial disparities to access to private medical care, as 72.9% of white South Africans have private medical care cover and only 9.9% of black South Africans.⁸ There are currently only two electrophysiologists in the South African public sector, and they are both based in Cape Town; the rest of the electrophysiologists are in the private sector. Therefore, most South Africans do not have access to cardiac electrophysiology services.

The spectrum and outcomes of interventional electrophysiology procedures in South Africa are unknown. Until recently, electrophysiology services in the South African public sector have been available only at Groote Schuur Hospital in Cape Town. The main objective of this study was to describe interventional electrophysiology procedures, the success rates and complications of catheter ablation procedures carried out in two South African quaternary centres and thus, define the feasibility of interventional electrophysiologic procedures in the South African public sector.

2 | METHODS

This study was a retrospective review of all electrophysiology procedures performed at Groote Schuur Hospital (GSH) and University of Cape Town Academic Hospital (UCTPAH) from 01 January 2013 to 31 December 2020. GSH is an 893 bedded public hospital affiliated with the University of Cape Town, and UCTPAH is a 124 bedded private hospital affiliated with the University of Cape Town. Interventional electrophysiology procedures at both GSH and UCTPAH are performed by a *European Heart Rhythm Association Certified Electrophysiology Specialist (ECES)* supported by an electrophysiology technologist and cardiac catheterisation laboratory staff. At GSH, electrophysiology catheters (except for 3d mapping catheters) are washed in an enzymatic solution containing protease amylase, lipase and cellulose; then washed in 6% hydrogen peroxide, gassed and re-sterilized for reuse, whereas at UCTPAH all electrophysiology catheters are used brand new. We specifically focused on catheter ablation procedures and outcomes thereof. The electrophysiology laboratory registry and electrophysiology reports were reviewed. A standardised data extraction form was used to collect data on the type of procedure, arrhythmia diagnosis, use of 3-dimensional mapping (3D mapping), presence and type of complications and acute outcomes. This study was approved by the University of Cape Town Human Research Ethics Committee, HREC REF: 184/2021.

a. Definitions

Acute success was defined at the end of the procedure. Acute success definition is dependent on the type of arrhythmia treated. Generally, acute success is defined as non-inducibility of previous induced arrhythmia or absence of ablated arrhythmia substrate such as an accessory pathway conduction after 30 min to 1h from the last ablation lesion.⁹ Atrioventricular Nodal Reentrant Tachycardia (AVNRT) was successfully ablated when slow pathway conduction was eliminated or when slow pathway conduction was limited to a single echo beat but no sustained tachycardia.¹⁰ For cavotricuspid isthmus (CTI) dependent atrial flutter and other macroreentrent flutters, acute success was defined by maintaining a bidirectional conduction block after the waiting period.¹¹ Success for atrial fibrillation was defined as exit and entrance block after pulmonary vein isolation. No adenosine or isoproterenol was used during the study period.¹²

2.1 | Statistical analysis

Statistical analyses were performed using SPSS Statistics for Macintosh version 24.0 (IBM, USA). Normally distributed continuous variables are reported as mean [standard deviations (SD)] and as median [interquartile ranges (IQR)] when skewed. Discrete data are presented as numbers and percentages. Pearson's chi-square was used to calculate the differences in the number of specific procedures performed between GSH and UCPAH. A *p*-value of <.05 was defined significance.

3 | RESULTS

During the study period, 1186 electrophysiology procedures were performed at GSH and UCTPAH. The overall patient population undergoing these procedures had a mean age of 54 (17) years at the time of the procedure, and 41% were females. However, patients treated at GSH were younger than patients treated at UCTPAH with a mean age of 49.5 (16.9) years vs 58.9 (15.0) years, p <.001. Further, there were more female patients treated at GSH than at UCTPAH, 50% vs 32%, p <.001.

Five hundred and ninety, 590 (49.7%) were performed at GSH and 596 (50.3%) at UCTPAH. There was a steady increase in the number of electrophysiology procedures performed per year from 2013 to 2018, with a decline in the number of procedures performed in 2019 and 2020 due to the coronavirus-2019 (COVID 19) pandemic (Figure 1). Catheter ablation for atrial fibrillation was the leading electrophysiology procedure performed, accounting for 27% of the procedures performed, followed by CTI-dependent flutter ablation (20%) and slow pathway ablation in AVNRT (14%) (Figure 2A,B).

One thousand one hundred two (1102) catheter ablation procedures were performed (after excluding negative electrophysiology studies and ventricular tachycardia stimulation). Seventy-six (76) of the catheter ablation procedures were redo procedures. Redo procedures were predominantly performed for atrial fibrillation ablation (30/76) in 39%, followed by accessory pathway ablation in (13/76) 17.1% and CTI-dependent atrial flutter in (9/76) 11.8%. Electroanatomical mapping (3D mapping) was utilised in 478/1102 (43.3%). CARTO (Biosense Webster Inc., Irvine, CA, USA: currently Johnson & Johnson, New Brunswick, NJ, USA) mapping system was utilised for 3D mapping in 95.4% (456/478), Ensite (St. Jude Medical, St. Paul, MN, USA; now Abbott, Abbott Park, IL, USA) mapping system was utilised in 3.8% (18/478), and Rhythmia (Boston Scientific, Cambridge, MA, USA) mapping system was utilised in 0.8% (4/478). Electroanatomical mapping was frequently used in AF ablation (66.5%), in ventricular tachycardia or premature ventricular complexes (16.3%), focal atrial tachycardias (9.2%) and atypical atrial flutters (4.6%). Electroanatomical mapping was less frequently used in catheter ablation of accessory pathways and CTI-dependent atrial flutter, which in combination accounted for less than 3% of 3D mapping cases. The overall success rate of catheter ablation in these two units was 92% (1014/1102). There were 9/1102 (0.8%) reported catheter ablation-related complications; these were six groin hematomas, two pericardial effusions and atrioventricular block requiring implantation of a permanent pacemaker.

3.1 | Atrial fibrillation

Overall, atrial fibrillation accounted for the most catheter ablation procedures performed during the study period, accounting for 28.9% (318/1102) (Figure 2A,B). The proportion of atrial fibrillation procedures increased between 2013 and 2020 (Figure 3). Most of the catheter ablation procedures for atrial fibrillation were performed at UCTPAH, 300 vs 18 at GSH, p < .001 (Figure 2A,B). Radiofrequency catheter ablation was used for AF ablation in 94.7% of the AF ablation procedures (301/318), and cryoablation was used in 5.3% (17/318). Pulmonary vein isolation (PVI) was the only approach to AF ablation in 78%, PVI plus CTI ablation in 21.4%, PVI plus CTI line, and a roofline or superior vena cava isolation in less than 0.5%. A 99% acute success rate was achieved with catheter ablation of AF (Figure 4).

3.2 | Cavotricuspid isthmus (CTI) dependent atrial flutter

CTI dependent atrial flutter was the second most common catheter ablation performed. CTI dependent atrial flutter ablation was performed in 238/1102 catheter ablation procedures (21.6%) and had a success rate of 96%. More CTI ablation procedures were performed at GSH than at UCTPAH, 156 vs 82, p < .001.

3.3 | Atrioventricular nodal reentrant tachycardia (AVNRT)

Catheter ablation for AVNRT accounted for 15.4% (170/1102) of catheter ablation procedures. There were more catheter ablation procedures for AVNRT performed at GSH than a UCTPAH, 112 vs 58, p <.001. The AVNRT were electrophysiologically classified as



FIGURE 1 Bar chart illustrating the number of electrophysiology procedures performed at Groote Schuur hospital and UCT academic, private hospital from 2013–2020, no: 1186.



slow-fast in 92.6%, slow-slow in 5.4% and fast-slow in 2.0%. The catheter ablation success rate for AVNRT ablation was 95%.

3.4 | Accessory pathway

Accessory pathway ablation procedures accounted for 10.9% (120/1102) of catheter ablation procedures. More accessory pathway ablation procedures were performed at GSH than at UCTPAH, 95 vs 25, p < .001. There were only three atypical accessory pathways during the study period, one atriofascicular accessory pathway and two fascicular ventricular accessory pathways. The fascicular ventricular accessory pathways were not ablated. Accessory pathway ablation was successful in 87% of the procedures.

3.5 | Premature ventricular complexes (PVCs)/ ventricular tachycardias (VTs)

During the study period, there were 78/1102 (7.1%) catheter ablation procedures for PVCs/VTs. These procedures were more frequently performed at GSH than at UCTPAH, 52 vs 26, p<.001. Idiopathic outflow tract arrhythmias accounted for most of these procedures (Figure 5). The overall success rate for PVCs/VT ablation was only 68%.

4 | DISCUSSION

The main findings of this study are (1) The trends of electrophysiology procedures and catheter ablation are rising; (2) There is a broad spectrum of electrophysiology procedures and catheter ablations performed in South Africa with high success rates and minimal complications; (3) There are significant differences in the patient population and type of ablation procedures performed in private and in the public sector.

Cardiac electrophysiology and catheter ablations have undergone an appropriate meteoric rise over the past three decades. Multiple registries from across the globe have reported increasing annual procedures, improving success rates and low complications.^{13,14} Advanced technology, innovative, practical techniques, and basic and clinical sciences understanding have steered this rapid progress and success. Today catheter ablation is the recommended first-line therapy for some forms of arrhythmias.¹⁵ Cardiac electrophysiology and catheter ablation services have been offered at Groote Schuur Hospital cardiac clinic since the late 1980s. Until as recent as 2017, the GSH cardiac clinic had been the only public or state sector unit offering comprehensive electrophysiology services in Sab-Saharan Africa.¹⁶

In the current study, we presented the catheter ablation experience in SSA. This is the first publication of this nature from SSA. At best, we present clinical outcomes that parallel international standards.¹⁷ For example, in a meta-analysis of catheter ablation for atrial flutter and supraventricular tachycardias by Spector and colleagues, the reported single procedure success rates for atrial flutter, accessory pathway, and AVNRT was 91%, 90% and 94%, respectively.¹⁸ Procedure safety is as important, if not more important, as the success rate. In the current study, there was only a 0.8% complication rate. In a single-centre prospective study to access the incidence and predictors of major complications related to catheter ablation, Bohnen and colleagues reported that rates of major complications differed between procedure types, ranging from 0.8% for supraventricular tachycardia, 3.4% for idiopathic ventricular tachycardia, 5.2% for atrial fibrillation, and 6.0% for VT associated with structural heart disease.¹⁷ In that study by Bohnen et al., ablation type (ablation for AF [odds ratio (OR) 5.53, 95% confidence interval (CI) 1.81 to 16.83], for VT with SHD [OR 8.61, 95% CI 2.37 to 31.31], or for idiopathic VT [OR 5.93, 95% CI 1.40 to 25.05] all referenced to supraventricular tachycardia ablation) and serum creatinine level >1.5 mg/dl (OR 2.48, 95% CI 1.07 to 5.76) were associated with increased adjusted risk of major complications.¹⁷ These authors report a higher complication rate, perhaps because they are a training and referral centre, with a substantial number of cases done by fellows and are more likely to take complex cases like ventricular tachycardias in patients with structural heart disease.

The current study reports significant differences in the patient population and a variety of ablation procedures performed in the private sector and the state or public sector. For example, patients treated at GSH were younger and more women than those treated at UCTPAH and the number of atrial fibrillation cases were disproportionately higher at UCTPAH. This is because of the perceived cost of catheter ablation for atrial fibrillation. However, numerous studies have shown



FIGURE 3 Stacked area chart demonstrating the evolution of catheter ablation procedures at GSH and UCTPAH from 2013 to 2020. No 1102. AF, Atrial Fibrillation; AVNRT, Atrioventricular Nodal Reentrant Tachycardia; AVN, Atrioventricular Node; CTI, Cavotricuspid Isthmus; MAT, Macroreentrant Tachycardia; PVC, Premature Ventricular Complex; sp, Slow Pathway; VT, Ventricular Tachycardia.



FIGURE 4 Bar chart demonstrating catheter ablation success rates for different arrhythmias and arrhythmia substrates. No 1102. AF, Atrial Fibrillation; AVNRT, Atrioventricular Nodal Reentrant Tachycardia; AVN, Atrioventricular Node; CTI, Cavotricuspid Isthmus; MAT, Macroreentrant Tachycardia; PVC, Premature Ventricular Complex; sp, Slow Pathway; VT, Ventricular Tachycardia.



11%

10%

10%

FIGURE 5 Pie chart demonstrating the substrate and or origin of PVCs or VT ablated at GSH and UCTPAH, no: 78. ARVC/D, Arrhythmogenic Right Ventricular Cardiomyopathy/Dysplasia; HCM, Hypertrophic Cardiomyopathy; LVOT, Left Ventricular Outflow Tract; RVOT, Right Ventricular Outflow Tract; TOF, Tetralogy of Fallot; VT, Ventricular Tachycardia.

that catheter ablation for atrial fibrillation is cost-effective compared to antiarrhythmic drugs, particularly over a five-year horizon or longer, particularly in symptomatic patients and heart failure patients.¹⁹ The perceived costs of catheter ablation are upfront procedure-related costs which are balanced out by the improved patient quality of life and reduced arrhythmia recurrences and hospitalisations.²⁰

The current study demonstrates that offering comprehensive and safe cardiac electrophysiology services in the South African public sector is highly feasible. A private-public partnership to train more cardiologists and electrophysiologists and government investment in technology and infrastructure to establish such centres in other parts of the country is essential to avail cardiology and cardiac electrophysiology services to the greater South African public.

5 | LIMITATIONS

The limitations of this study are its retrospective and single-centre design. Further, we do not have details on admission duration, procedure time and radiation time. The low complication rates could also be due to the study's retrospective nature and that some of the complications, particularly late complications, would not have been documented in the electrophysiology report.

6 | CONCLUSION

This study aimed to determine the spectrum and outcomes of interventional cardiac electrophysiology procedures performed in two South African units, one in the public sector and the other in the private sector. We found that a broad spectrum of interventional procedures was performed with a reasonable success rate and a limited frequency of complications, thus resembling international standards. There is a discrepancy between the procedures undertaken in the public and private sectors, particularly atrial fibrillation ablation. This discrepancy is partly due to the perceived high cost of atrial fibrillation ablation in the public sector.

AUTHOR CONTRIBUTIONS

This paper has not been submitted for publication in any other journal. All authors have made a significant contribution and have read and approved the final draft. PM designed the study, collected the data and drafted the manuscript. NB and KS collected the data and drafted the manuscript. AC contributed in the interpretation of data and revised the manuscript critically for important intellectual content.

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CONFLICT OF INTEREST

All authors have no conflicts of interest to declare.

DATA AVAILABILITY STATEMENT

The datasets used and analysed during the current study are available from the corresponding author on reasonable request.

ETHICS STATEMENT

This study was approved by the University of Cape Town Human Research Ethics Committee, HREC REF: 184/2021.

CONSENT TO PARTICIPATE

All patients provided a written Informed consent catheter ablation procedure.

Not applicable.

CODE AVAILABILITY

Statistical analysis was performed using SPSS® version 24 (IBM Corp, Armonk, NY).

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