

ORIGINAL ARTICLE

LOCALIZATION OF ACCESSORY PATHWAYS IN WOLFF PARKINSON WHITE SYNDROME USING R/S RATIOS ON SURFACE ECGs

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Background: This study was conducted to establish the accuracy of R/S ratios in localizing accessory pathways in Wolff Parkinson White Syndrome on surface ECGs. **Methods:** This was a retrospective cross-sectional study from January 2002 till December 2016 conducted at National Institute of Cardiovascular diseases in Karachi, Pakistan. The sample included 157 patients with manifesting Wolff Parkinson White (WPW) Syndrome on a 12-lead surface ECG. As per the inclusion criteria, patients who had persistent or intermittent pre-excitation on surface ECG and had undergone electrophysiological study (EP) were included in the sample. Individuals with both successful and unsuccessful ablation procedures were included. **Results:** The sample consisted of 62.4% males (n=98) and 37.6% females (n=59) with mean age being 35.36 ± 12.44 . Accessory pathways (APs) were identified on the left side in majority of the patients with 54.1% (n=85) while right sided pathways were seen in 42.1% (n=66). Moreover, the most common accessory pathway amongst the males was Left Anterior (LA) and Left Lateral (LL) with a percentage of 48%, followed by Right Posteroseptal (RPS) at 20.4%. As opposed to this, the most common pathways amongst the females turned out to be RPS at 33.9% followed by LL and LA at 32.2%. Furthermore, the test using ratios were most effective in identifying left sided APs with sensitivity 74.1% and was least sensitive in identifying right sided pathways (sensitivity=40.7%). However, it was highly specific in locating right sided pathways with specificity of 94.6% as opposed to 83.3% in the left side. Furthermore, mid-septum regions had a sensitivity and specificity of 66.7% and 69.6% respectively. **Conclusion:** This establishes the effectiveness of R/S ratios in determining the location of accessory pathway based on the surface ECG prior to the ablation procedure. Since the younger population is affected more commonly, prolonged exposure to ionizing radiation can cause long term complications therefore, by this means, the duration of exposure can be reduced.

Keywords: Wolff Parkinson White Syndrome; Accessory pathways; Surface ECG; Electrophysiology ablation

Citation: Jamal SZ, Zaidi KA, Sheikh SA, Ahmed A, Irfan G, Qadir F. Localization of accessory pathways in Wolff Parkinson White Syndrome using R/S ratios on surface ECGs. J Ayub Med Coll Abbottabad 2019;31(2):146–50.

INTRODUCTION

Wolff Parkinson White (WPW) Syndrome is a cardiac conduction abnormality associated with an accessory pathway between the atria and the ventricles.¹ This pathway bypasses the atrioventricular (AV) node and allows early depolarization of the ventricle causing premature ventricular activation also known as preexcitation.² The WPW syndrome was first described in 1930, as a syndrome that manifests with a short PR interval (<120 milliseconds in adults), wide QRS complex (>120 milliseconds), slurred slow rising onset of the R wave upstroke (Delta Wave) along with episodes of tachycardia on the surface electrocardiogram (ECG). WPW Syndrome is known to primarily affect young patients in the absence of structural cardiac abnormality.³

The accessory pathway (AP) occurs due to incomplete separation of atria and ventricles during their formation and is therefore congenital. It consists of a thin filamentous structure that persists along the atrioventricular groove, most commonly affecting the

left lateral side.⁴ These APs can be classified according to their site, direction and the number of pathways.⁵

Since it primarily affects the young population, long term use of anti-arrhythmics for prophylaxis was unacceptable. However, its association with a high risk of sudden cardiac death urged for anticipatory measures.⁶ Therefore, radiofrequency catheter ablation is now considered treatment of choice for WPW Syndrome due to its effectiveness.⁷ However, success of the electrophysiological study, involving ablation, relies primarily on the location of the accessory pathway. Prior identification of the exact location not only prevents prolonged exposure to ionizing radiations but also allows for a faster, safer and more efficient procedure.⁸

Several algorithms have been formulated to predict the precise location of an AP on a surface ECG.^{9,10} These algorithms vary in their predictive values as some are based on the delta wave morphology and others on the QRS polarity. However, studies have shown that an algorithm based on the R/S ratio in the

ECG has reported rapid identification with high sensitivity and specificity.¹¹

The aim of this study is to assess the discriminative ability of R/S ratio algorithm in correctly predicting the location of accessory pathway based on an ECG followed by confirmation on an electrophysiological study.

MATERIAL AND METHODS

The sample size consisted of 157 patients with manifesting Wolff Parkinson White (WPW) Syndrome on a 12-lead surface ECG. This was a retrospective cross-sectional study conducted at National Institute of Cardiovascular Diseases in Karachi, Pakistan. Ethical approval was obtained by the hospital’s ethical review committee. Consent was taken from the patient before the procedure was performed. Confidentiality and anonymity were maintained. Data was only accessible to the researchers. Secondary data was obtained from January 2002 till December 2016. As per the inclusion criteria, patients who had persistent or intermittent pre-excitation on surface ECG and had undergone electrophysiological study (EP) were included in the sample. Individuals with both successful and unsuccessful ablation procedures were included. In accordance with the exclusion criteria, all the patients who were found to have multiple pathways on EP study were removed from the sample.

The accessory pathway locations were determined after ablation in 6 specific regions namely; i) Left Lateral (LL) and Left Anterior (LA), ii) Left Posterior (LP) and Left Posterolateral (LPL), iii) Right and Left Midseptum and Posterior Septum, iv) Right Posterior (RP) and Right Posterolateral (RPL) and v) Right Anterior (RA), Right Lateral (RL) and Right Anteroseptal (RAS) and Right Posteroseptal (RPS).

A simple algorithm reported by Naguchi *et al* based on only R/S ratios was used for the prediction of accessory pathways in our study.¹¹ A standard 12 lead ECG was recorded during sinus rhythm before the induction of tachycardia for the ablation procedure. In ECGs with the most overt preexcitation, the peak amplitudes of V1, V2 and aVF were recorded. The R/S ratio was obtained by dividing amplitude of the R wave with amplitude of the S wave. If S wave was not recordable, amplitude was considered 0.1mV.

Data was entered and analyzed on SPSS Version 20. Qualitative variables were documented in frequency and percentages. Quantitative data was assessed in mean and standard deviation. Associations have been established using Chi Square with *p*-value <0.05 taken as significant.

RESULTS

This sample was distributed with respect to age, with mean age being 35.36±12.440. The sample included 98

male and 59 female participants with mean age of males being 35.57±12.82 and females with mean age being 36±11.89. There was no significant difference in the mean age of two groups with independent t-test value=0.778. Accessory pathways were identified on the left side in majority of the patients with n=85 (54.1%) while right sided pathways were seen in n=66 (42.1%). Pathways were found in the MS region in 6 individuals (3.8%). The most common anatomical location determined upon ablation, turned out to be Left Lateral and Left Anterior Segment with n=66 (42%) while the second most common location was identified as Right Posterior Septum with n=40 (35.5%). Left posterior and Left postero-lateral presented with n=19 (12.1%) presented as the third most common position followed by Right postero-lateral and Right posterior in 15 subjects. Right Anterior, right lateral and right anteroseptal presented in n=11 (7%). Midseptum was found to be least common in our sample with n=6 (3.8%).

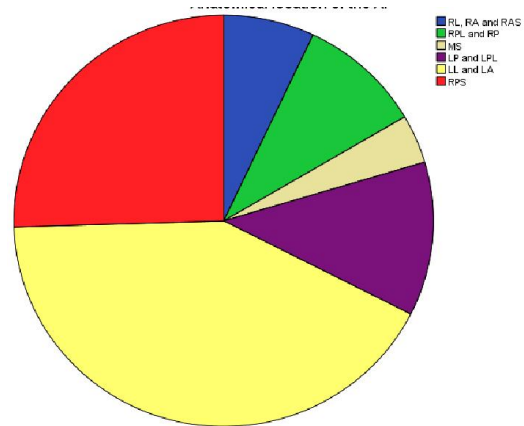


Figure-1: Anatomical Locations of Accessory Pathways.

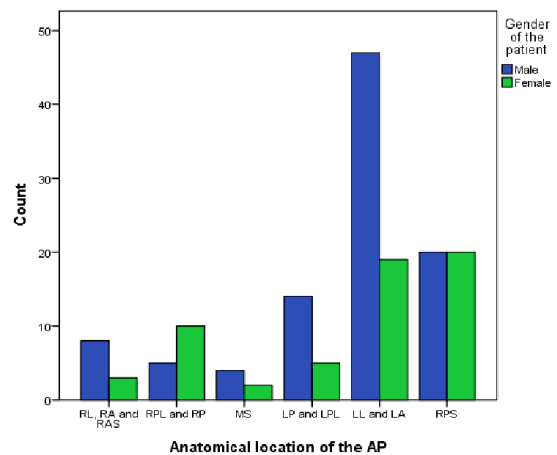


Figure-2: Variation in anatomical locations based on gender

The most common accessory pathway amongst the males was Left anterior and left lateral with a percentage of 48%, followed by Right posteroseptal at 20.4%. The most common pathways amongst the females turned out to be RPS at 33.9% followed by LL and LA at 32.2%. The least common pathway amongst both males and females was MS, however, amongst the entire population of patients with MS, 66.7% were males. Hence, a significant association was found between the gender of the patient and the location of AP at p -value=0.038.

The right femoral vein approach was applied in 69 of the cases which included all 66 right sided accessory pathways as well as 3 which were in the MS region. Trans-septal approach was used in 58 (36.9%) subjects while retrograde aortic was the least commonly used approach, having been used in 30 patients (19.1%). The approach used was significantly associated with the anatomical location of the accessory pathway at p -value=0.000. Approach via the right femoral vein for ablation of accessory pathway was successful in 40 patients (58%) while trans-septal had the highest success rate with 77.6% Retrograde aortic, even though not a very commonly used procedure, had a success rate of 60%.

66.1% of the females underwent a successful ablation procedure as opposed to 65.3% of the males whose procedure was successful. The association was significant with p =0.01. Furthermore, amongst the 103 patients with successful ablations, 62.1% were males and 37.9% females.

Particular locations of accessory pathways had higher success rates compared to others. LP and LPL had the highest success rate with 78.9% of the APs in that area successfully ablated. RPL and RP had the second highest success rate of 73.3%. Even though LL and LA were the most commonly found location, success rate during ablation was 69.7%. APs located in the RPS had a 65% success rate followed by MS and RA, RL and RAS with 33.3% and 27.3% respectively. Therefore, a significant association was found between the site of accessory pathway and success rate of ablation at p -value=0.031. The accessory pathways during ablation were localized in the six regions mentioned earlier but for localization via the algorithm on surface ECG, RPS accessory pathways were considered with the MS and PS.

Table-1: Association between anatomical location of AP and ECG leads

Anatomical Location	V1		V2		aVF	
	<0.5	≥0.5	<0.5	≥0.5	<1	≥1
RA, RL, RAS	11	0	6	5	1	10
RP and RPL	15	0	6	9	6	9
MS and PS	34	12	5	41	25	21
LP and LPL	5	14	0	19	2	17
LL and LA	16	50	5	61	2	64

Table-2: Validity of the R/S ratio algorithm

Location	Sensitivity	Specificity	PPV	NPV
Left side	74.1	83.3	84	73.2
Mid-septum	66.7	69.6	46.9	83.9
Right side	40.7	94.6	61.1	88.5

Table-1 lists the values of V1, V2 and aVF in patients who presented with accessory pathways of the aforementioned anatomical locations. Results have shown that right sided pathways showed V1<0.5 in all 26 cases. 12 of these 26 cases had V2<0.5 and 5 had aVF≥1 and were correctly identified in the RAS, RA and RL region. 34 individuals from the right and left MS and PS region had V1<0.5, out of these 29 had V2≥0.5 which correctly identified 85.3% of accessory pathways located in the MS and PS. Moreover, amongst the left sided pathways, 76 were found to have V1≥0.5, out of which 64 had aVF≥1 and were correctly identified as LA and LL (84.2%). However, majority of the LP and LPL also had aVF≥1 so it was difficult to distinguish between the sites.

Table-2 shows the validity status of this R/S ratio-based algorithm in determining the side of the heart in which the accessory pathway is located. The test was most effective in identifying left sided APs with sensitivity 74.1% and was least sensitive in identifying right sided pathways (sensitivity=40.7%). However, it was highly specific in locating right sided pathways with specificity of 94.6% as opposed to 83.3% in the left side. Moreover, mid-septum regions had a sensitivity and specificity of 66.7% and 69.6% respectively.

DISCUSSION

Wolff Parkinson White Syndrome belongs to a class of supraventricular arrhythmias and is used for patients who have pre-excitation and symptomatic tachyarrhythmias.⁷ According to recent studies, the prevalence of WPW syndrome in the population has been reported as 0.3% while the associated risk of sudden death ranges from 0.5% to 4%.¹² The most common arrhythmia found in patients with WPW was atrio-ventricular reciprocating tachycardia (AVRT) in 75% of the population. In our study, only the patients presenting with AVRT were included. Accessory pathways can be classified based on their location and direction of conduction. Usually, accessory pathways capable of retrograde conduction have concealed pathways and were excluded from our study. However, pathways with anterograde conduction with manifest WPW were present in our sample.⁷

WPW is a congenital disease and hence presents more commonly in young adults, our study sample had a mean age of 35.36±12.44. A significant

difference has also been reported in the WPW pattern based on gender. There is a higher prevalence amongst males. Our study consisted of 62.4% males which was comparable with the results published in another study that estimated the prevalence in males to be 60.90%.¹⁴

Left sided accessory pathways are the most commonly found APs irrespective of demographic factors.¹⁵ Our study also reported that 54.1% of the pathways were on the left side. However, contrary to previous studies that have shown right sided accessory pathways in 20% of the population, our sample consisted of n=66 individuals (42.1%) with right sided Aps.¹⁶ The difference between results from two provinces in Pakistan can be explained by the difference in ethnicities as another study conducted in Karachi, also reported 39% right sided accessory pathways.¹⁷ Amongst the left sided pathways, left lateral and left anterior were found in 42% of the patients and hence, were the most commonly localized pathways. Our study reported pathways in the right postero-septal region in 35.5% of the sample which is similar to the 30% reported in earlier studies.¹⁸

There was a significant association between the gender of the patient and the accessory pathway ($p=0.038$). Left anterior and Left lateral was found in 48% of the males followed by RPS (20.4%). Whereas, RPS was found in 33.9% of the females followed by LL and LA pathways in 32.2%. The least common pathway amongst both genders is the MS pathway, while males are generally predominant in the patients with this particular pathway.

Studies have reported an overall success rate of ablation procedures ranging from 93 to 95%. However, our study revealed a success rate of 65.6% which is in contradiction with other recent studies. The success rates were also associated with locations of the accessory pathways. In accordance with previous studies, highest success rate was recorded for left free wall accessory pathways, with LP and LPL successfully ablated in 78.9% and LL and LA were at 69.7%. According to our study, RPL and RP had the second highest success rate of 73.3% and RPS 65% which was contrary to the existing studies. Therefore, the site of accessory pathways is significantly associated with the success rate of ablation ($p=0.031$).¹⁹⁻²¹

Our study showed a sensitivity of 74.1%, 66.7% and 40.7% in detecting APs left side, mid septum and right side respectively. Our results were comparable with various other studies that have shown a notably lower sensitivity and specificity for these algorithms.²²⁻²³

This could possibly be based on the subjective interpretation of the surface ECG during

application of these algorithms. Moreover, differences in the application of ECG leads on the surface of the body or even any mild changes in the position or the normal morphology of the heart can lead to different findings in the ECG.¹⁶ However, this was noted by Fox *et al* that some algorithms were more accurate in predicting APs correctly at specific sites but would lead to an error when the APs were located at different sites such as septal pathways.¹³ Thus, the only reliable and accurate parameter in detecting the exact location of the accessory pathway is a successfully performed AP ablation. However, the catheter ablation procedure has got its own drawbacks. Several complications can result due to vascular approach such as perforation of the vessel, AV fistulas, Deep vein thrombosis etc. Furthermore, problems can arise due to usage of the catheters such as coronary dissection, valvular damage, microemboli formation. Other less frequent complications can arise due to improper application of radiofrequency energy.⁷ Studies have reported an overall incidence of complications between 1–4% while procedure related deaths have been estimated to be less than 0.2%.²⁰

CONCLUSION

This study establishes the effectiveness of R/S ratios in determining the location of accessory pathway based on the surface ECG. This can be done prior to an ablation procedure to make the process more efficient. Since the younger population is affected more commonly, prolonged exposure to ionizing radiation can cause long term complications therefore, by this means, the duration of exposure can be reduced. Furthermore, using these ratios will make the procedure more efficient, faster and safer for the patient. Thus, this simple procedure should definitely be considered in order to improve the approach to the patient during a radiofrequency ablation.

AUTHORS' CONTRIBUTION

SZJ: Concept, study design, data analysis, interpretation, proof reading. KAZ: Study design, data collection, analysis, interpretation, write-up. SAS: Data collection, analysis, interpretation. AA: Data collection, interpretation, write-up. GI & FQ: Data collection, proof reading.

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Submitted: 25 January, 2018

Revised: -

Accepted: 28 October, 2018

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