Original Article

Pak Armed Forces Med J 2016; 66(Suppl):S63-68

COMPARISON OF ECG ALGORITHMS FOR IDENTIFYING ACCESSORY PATHWAY ABLATION SITE IN WOLFF-PARKINSON-WHITE SYNDROME

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ABSTRACT

Objective: To evaluate and compare the accuracy of two ECG algorithms in predicting accessory pathway location by comparing the final accessory pathway location after radiofrequency catheter ablation.

Study Design: A cross sectional study.

Pace and Duration of Study: The study was conducted at Armed Forces Institute of Cardiology & National Institute of Heart Diseases from January 2014 to December 2015

Material and Methods: A total of 120 patients with Wolf-Parkinson White syndrome were retrospectively analyzed by two independent electrophysiologists. The most pre-excited twelve lead ECG in sinus rhythm was used for analysis. Two algorithms were selected for comparing the accuracy of predicting accessory pathways. The Arruda ECG algorithm included delta wave polarity in its design while the Taguchi ECG algorithm included R/S ratio.

Results: Among all locations 55 (45.8%) were left sided and 65 (54.2%) were right sided. Out of total 120 accessory pathways, 14 (11.7%) were located in the midseptum or anteroseptum. In all, 105 (87.5%) predictions were correct for Arruda, and 94 (78.3%) for Taguchi. The predictive accuracy for Arruda algorithm based on delta wave was found to be significantly higher as compared to Taguchi algorithm based on R/S ratio (p 0.01). By combining the two algorithms, the cumulative predictive accuracy increased to 91.6%.

Conclusion: ECG algorithm based on delta wave morphology / polarity had better predictive accuracy in identifying the accessory pathway location in Wolf-Parkinson White syndrome.

Keywords: Ablation, ECG algorithms, Wolf-Parkinson White syndrome.

INTRODUCTION

Wolf-Parkinson and White Syndrome (WPW) is the most widespread type of pre-excitation syndrome which is associated with an accessory AV connection, called Kent Bundle. Catheter ablation of antrioventricular accessory pathways has become the preferred therapy for patients with Wolff-Parkinson-White syndrome[1]. To facilitate the planned ablation and to minimize catheter related injury, it is vital to predict the accessory pathway location based on analysis of a 12-lead electrocardiogram demonstrating preexcitation. Localization of accessory pathways can be anywhere around the antriventricular annuli, left or right sided, or within the septum. The common features of surface ECG comprises of a shortened PR interval for age i.e less than 120 milliseconds in adults; prolonged QRS duration for age i.e more than 120 milliseconds in adults and a slurred slow rising onset of R wave upstroke known as Delta wave[2]. For predicting the accessory pathway location several algorithms have been proposed, based on the analysis of QRS and delta wave morphology on the 12-lead electrocardiogram[2-7]. Majority of the algorithms are related to delta wave morphology as it depends upon the localization of ventricular insertion of the accessory pathway which is the site of initiation of ventricular activation[3]. However these algorithms are rather complex and an accurate determination of delta wave morphology is sometimes difficult[8]. On the other hand ECG algorithms based on the QRS polarity are comparatively easier to understand but their accuracy is still limited. Thus, literature reports

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inconsistent and inaccurate results with these two types of ECG algorithms.

Therefore, the aim of this study was to evaluate the accuracy of two ECG algorithms in predicting the accessory pathway locations in adult patients with Wolff-Parkinson-White syndrome by comparing the predicted and final accessory pathway locations after performing radiofrequency catheter ablation. One of the two algorithms was based on delta wave (Arruda et al. 1998)[3], while the other involved R/S ratio (Taguchi et al. 2014)[8].

MATERIAL AND METHODS

Study population

One hundred and twenty patients with Wolff-Parkinson-White syndrome who underwent catheter ablation at our institution from April 2014 to March 2015 were retrospectively analyzed. Patients under the age of 18, with congenital heart defects, multiple accessory pathways, concealed pathways and unsuccessful ablations were excluded. A resting 12 lead ECG with clear preexcitation at paper speed of 25 mm/sec on a standard grid thermal paper was obtained for interpretation. The study was approved by Institutional Ethical and Review Board (IERB). IERB waived the requirement to obtain signed consent from enrolled patients.

ECG algorithms

Two algorithms were selected for comparing the accuracy of predicting accessory pathways. The Arruda ECG algorithm included delta wave polarity in its design while the Taguchi ECG algorithm included R/S ratio.

Arruda algorithm

Arruda et al[2] developed an algorithm by analyzing retrospective ECGs of 135 adult patients of WPW syndrome. The algorithm was then further tested on 121 patients. This algorithm comprised of following four steps:

Step 1: If either the delta wave in lead I is negative or isoelectric or the R wave is greater in amplitude than the S wave in lead V1, a left freewall accessory pathway was present. If this criterion was fulfilled, lead aVF was examined. If the delta wave in lead aVF was positive, a left lateral/anterolateral (LL/LAL) accessory pathway was identified. If a delta wave in lead aVF was isoelectric or negative, the accessory pathway was located at the left posterior/posteroiateral (LP/LPL) region. If the criteria in leads I and V1 are not fulfilled, a septal or right free-wall accessory AV pathway is identified.

Step 2: Lead II was examined. A negative delta wave in lead II identified the subepicardial posteroseptal accessory pathway. If the delta wave in lead II was isoelectric or positive, proceeded to step 3.

Step 3: Lead V1 was examined. A negative or isoelectric delta wave in lead V1 identifies a septal accessory pathway. If this criterion was fulfilled, lead aVF wais examined. If the delta wave in lead aVF was negative, an accessory pathway was identified, which wais located at the posteroseptal tricuspid annulus or at the coronary sinus ostium and surrounding region (PSTA/CSOs). If the delta wave was isoelectric in lead aVF, the accessory pathway may be located close to either the posteroseptal

Table-1: Distribution of accessory pathway locations in our study population.

S. No.	Accessory pathway location	Total n = 120	
		Right sided ap N = 65	Left sided AP N = 55
1.	Lateral (free-wall)	-	20 (36.3%)
2.	Posteroseptal accessory pathway	26 (43.3%)	4 (7.2%)
3.	Posterior accessory pathway	12 (20%)	4 (7.2%)
4.	Posterolateral accessory pathway	8 (13.3%)	16 (29%)
5.	Anteroseptal accessory pathway	8 (13.3%)	-
6.	Anterolateral accessory pathway	6 (10%)	2 (3.6%)
7.	Midseptal accessory pathway	5 (8.3%)	9 (16.3%)

tricuspid annulus (PSTA) or the posteroseptal mitral annulus (PSMA). A positive delta wave in aVF identified a pathway located within the anteroseptal/right anterior para septal (AS/RAPS) or mid-septal tricuspid annulus (MS) regions.

These two regions are differentiated by examining the R/S ratio in lead III: R > S identifies anteroseptal/right anterior paraseptal (AS/RAPS) accessory pathway, and R < S identifies an accessory pathway located along the mid-septal tricuspid annulus (MSTA). If the delta wave in lead V1 was positive (after having excluded patients with a left free-wall accessory pathway in Step 1), a right free-wall accessory AV pathway is identified.

Taguchi algorithm

Taguchi et al. developed an algorithm by analyzing R/S ratios in lead V1, V2 and aVF on ECGs of 142 patients with a single anterogradely conducting accessory pathway. Stepwise ECG algorithm is shown in figure 1.

Step 1: The R/S ratio in lead V1 is examined. If the R/S ratio in lead V1 is 0.5 or more, the AP is located in the freewall region of the mitral annulus (LA/LL or LPL/LP region). Proceed to Step 2. If the R/S ratio in lead V1 is less than 0.5, the AP is located in the free wall region of the tricuspid annulus or septum. Proceed to Step3.

Step 2: The R/S ratio in lead aVF is examined. If the R/S ratio in lead aVF is 1 or

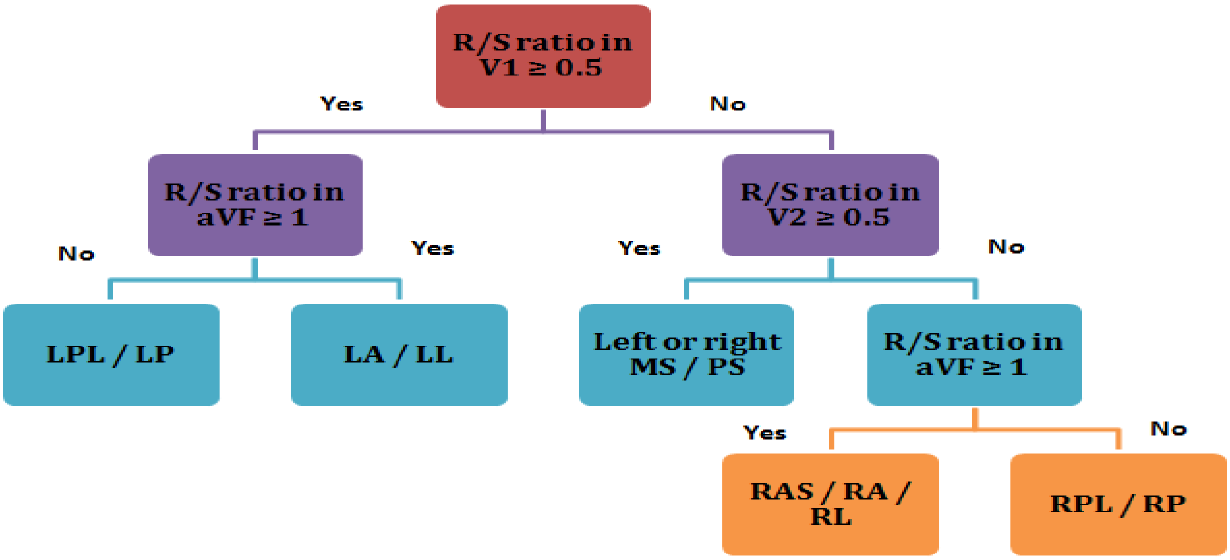

Figure-1: Stepwise Taguchi et al. ECG algorithm for the determination of accessory pathway locations. Abbreviations: LA: left anterior; LL: left lateral; LP: left posterior; LPL: left posterolateral; MS: midseptal; PS: posteroseptal; RA: right anterior; RAS: right anteroseptal; RL: right lateral; RP: right posterior; and RPL: right posterolateral.

Step 4: In patients with right free-wall accessory pathways, examine lead aVF. A positive delta wave in lead aVF identified a right anterior/anterolateral accessory pathway (RA/RAL). If the delta wave in aVF was isoelectric or negative, examine lead II. A positive delta wave in lead II identified a right lateral accessory pathway (RL) and an isoelectric delta wave in lead II identified a right posterior/posterolateral accessory pathway (RP/RPL).

more, the AP is located in the LA/LL region. If it is less than 1, the AP is located in the LPL/LP region.

Step 3: The R/S ratio in lead V2 is examined. If the R/S ratio in lead V2 is 0.5 or more, the AP is located in the left or right MS/PS region. If the R/S ratio in lead V2 is less than 0.5, the AP is located in the RAS/RA/RL region or the RPL/RP region. Proceed to Step 4.

Step 4: The R/S ratio in lead aVF is examined. If the R/S ratio in lead aVF is 1 or more, the AP is located in the RAS/RA/RL region. If it is less than 1,the AP is located in the RPL/RP region.

Electrocardiographic analysis

Two cardiologists experienced in electrophysiology analyzed patient's ECG according to the above mentioned algorithms. Both observers were blinded to the patient's name and accessory pathway location determined by electrophysiology study. The final localization of the accessory pathway location was determined by biplane fluoroscopy at the time of catheter ablation. Incorrect locations those were adjacent to the exact location were accepted i.e. left lateral predicted as left posterior/left posterolateral. If the predicted accessory pathway site was right-sided but the actual accessory pathway was left-sided or the predicted location was left-sided but the exact location was right-sided, it was accepted as incorrect side (contralateral to the exact location).

Statistical analysis

The data were entered in IBM SPSS Statistics software (version 19). Continuous data were expressed as median and mean along with standard deviation values. Proportions were expressed as percentages with confidence intervals of 95%. Different groups were compared with either chi-square test or a non-parametric Fisher's exact test. Similarly groups of continuous variables were compared by using student's t-test or a non-parametric Wilcoxon - Mann - Whitney test. The inter - observer agreement is calculated by the kappa – statistic.

RESULTS

Mean age of the study population was 37 ± 12.8 years and there were 90 (75%) males and 30 (25%) females with male to female ratio of 3:1. 90% (n=108) of the patients presented with history of tachycardia while remaining had incidental ECG findings of WPW pattern.

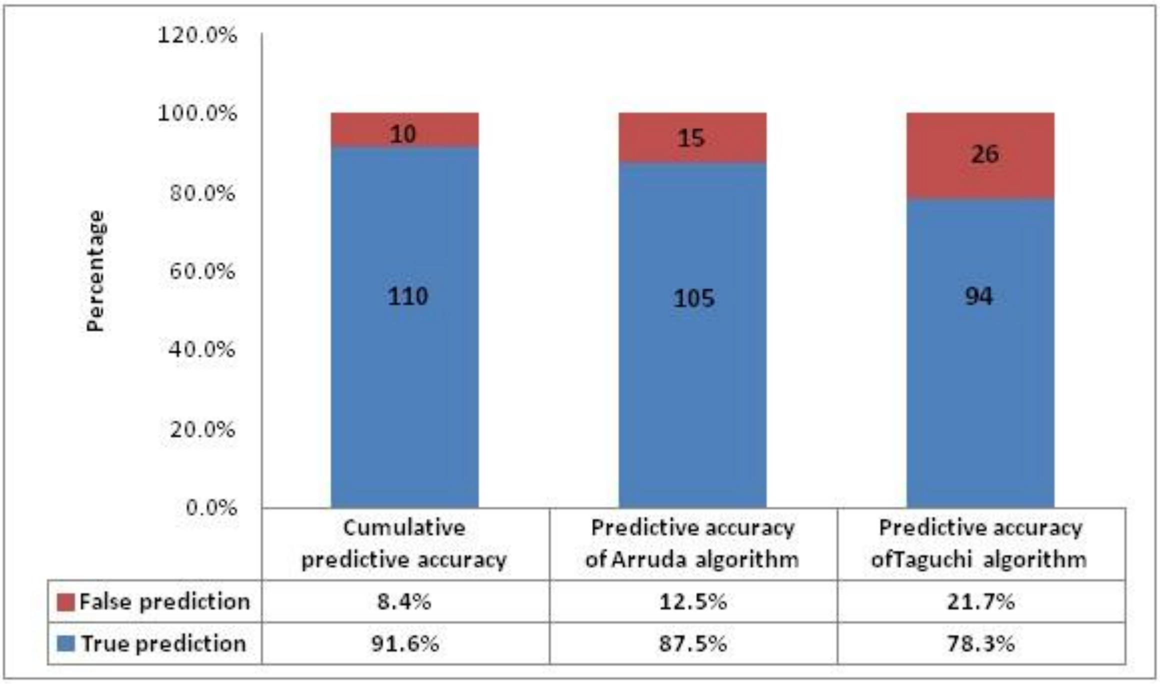

Figure-2: Success rate of predicting accessory pathway location of two ECG algorithms.

Accessory pathway locations determined by the electrophysiological study are shown in Table-1. Among all locations 55 (45.8%) were left sided and 65 (54.2%) were right sided. Out of total 120 accessory pathways, 14 (11.7%) were located in the midseptum or anteroseptum. Among right sided accessory pathways (n=65), posteroseptal was the most common location as it was found in 26 patients contributing 43.3%, 12 (20%) had right posterior, 8 (13.3%) had right posterolateral, 8 (13.3%) had right anteroseptal, 6 (10%) had right anterolateral and 5 (8.3%) had right midseptal accessory pathway location as shown in fig-2. Among left sided accessory pathways (n=55), 20 (36.3%) patients had left lateral (free-wall) location while 16 (29%), 9 (16.3%), 4 (7.2%), 4 (7.2%) and 2 (3.6%) had left posterolateral, left midseptal, left posterior, left posteroseptal and left anterolateral locations respectively as shown in Table-1. If the predicted accessory pathways were classified according to the site of the location e.g. right sided, left sided and anteroseptal / midseptal, then the best algorithm for prediction of right and left sided accessory pathways was Arruda (*p* 0.001).

In all, 105 (87.5%) of predictions were correct for Arruda, and 94 (78.3%) for Taguchi. The predictive accuracy for Arruda algorithm based on delta wave was found to be significantly higher as compared to Taguchi algorithm based on R/S ratio (p 0.01). By combining the two algorithms, the cumulative predictive accuracy increases to 91.6%.

The average inter - observer agreement ratio was 95.05% with kappa index of $\kappa = 0.7$, indicating good strength of agreement. The strength of agreement between two pairs ranged from moderate ($\kappa = 0.5$) to excellent ($\kappa = 0.9$).

DISCUSSION

In this study, predictive accuracy for Arruda et al. ECG algorithm involving delta wave is found to be significantly better as compard to Taguchi et al. algorithm based on R/S ratio (*p* 0.01). Arruda showed a better accuracy in predicting left sided, right sided and mid-septal/antero-septal accessory pathways than Taguchi. However, observed accuracy for both the algorithms was lower than the reported accuracy by respective authors. Arruda et al[3] reported a success rate of 90% for predicting accessory pathway location where as we have observed 87.5% success rate in our study. Similarly, Taguchi et al[8] reported 93% success rate while our observed rate is calculated to be 78.3%.

Delta wave morphology reflects the ventricular attachment site of accessory pathway, and the R/S ratio also depends on the accessory pathway location. But the R/S ratio can vary in nature when there are timing differences between accessory pathway condction and atrioventricular nodal conduction[9-12]. It is reported in various studies that interpretation of delta wave polarity is very subjective in nature and is difficult to access[10-14], but Arruda et al. has provided a detailed schematic scheme explaining positive, negative and isoelectric delta waves that may help the interpreters in making more precise analysis. Therefore, the analysis of delta wave morphology may identify the accessory pathway location more accurately.

Basiouny et al. concluded that the algorithms that did not include delta wave polarity assessment in their architecture had lower accuracy in predicting accessory pathways[15]. Similar sort of results are observed in our study, lower accuracy rate for Taguchi may be explained by the former reason. Taguchi et al categorized accessory pathways in limited number of locations as shown in fig-1, that can also be a reason for its poor performance.

CONCLUSION

ECG algorithm based on delta wave morphology/polarity had better predictive accuracy in identifying the accessory pathway location in Wolf-Parkinson White syndrome.

CONFLICT OF INTEREST

This study has no conflict of interest to declare by any author.

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