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Validation of New Algorithm to Localize the Site of the Accessory Pathway in Patients with Wolf Parkinson White syndrome Using Surface ECG

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Keywords: **Wolf Parkinson White syndrome, WPW, surface ECG, accessory pathway**

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ABSTRACT

Background: In patients with Wolf Parkinson White syndrome, localization of the site of accessory pathway using surface ECG is an important step prior to any Electrophysiological study and ablation therapy.

Aims: To validate a new and simple stepwise algorithm in localizing the accessory pathway site using the surface ECG during sinus rhythm.

Materials and Methods: A prospective study was conducted among patients with Wolf Parkinson White syndrome scheduled for electrophysiological study and ablation therapy at a single center from January 2015 to February 2019. The surface ECG of patients with Wolf Parkinson White syndrome, taken one day prior to the Electrophysiological study, were used to apply this algorithm to localize the site of accessory pathway and compare it with the results of Electrophysiological study next day.

Results: The total number of patients enrolled in the study were 121;, of which 73 were males (60.3 %) and 48 females (39.7 %), with a mean age of 33 ± 12 years & range of 13- 69 years. Overall sensitivity and specificity of this algorithm in detecting the site of accessory pathway, using successful ablation site as a reference test, were 94% and 98%, respectively, and the positive and negative predictive values were 90% and 99%, respectively.

Conclusion: This new algorithm to localize the site of the accessory pathway in patients with Wolf Parkinson White syndrome using surface ECG is easily applied and has good sensitivity and specificity.

INTRODUCTION

Approximate localization of accessory pathway (AP) site using pre-excitation pattern is an important pre-requisite for electrophysiological study (EPS) and catheter ablation, to guide the strategy of EPS and ablation and to anticipate the possible complications. Several algorithms have been developed to detect the anatomic site of manifested AP based on delta wave and QRS polarity on surface Electrocardiogram (ECG) [1-6].

Most of the published algorithms did not report acceptable levels of sensitivity and/or specificity for all accessory pathway's locations [6,7]. Therefore, we plan this study with an aim to validate a new & simple stepwise algorithm in localizing AP site using the surface ECG during sinus rhythm.

MATERIALS AND METHODS

Study population: The population for study consisted of a convenient sample of patients who underwent successful catheter ablation for manifest AP at Nassiriya Heart Centre from January 2015 through February 2019. Patients with multiple antegrade AP conduction, with structural heart disease and those with failed ablation were excluded. All anti arrhythmic drugs were discontinued for at least 5 half-lives before the study.

Study design: The proposed algorithm was developed over a period of two years starting in 2012 and applied at Nassiriya Heart Centre (along with the existing algorithms) and a prospective assessment and validation of the new algorithm was done by the means of this study.

The ECG criteria adopted in this study for localizing the AP were as follow (figure 1)

1. Using the QRS vector in the chest leads
    a. Predominantly positive V1-V4 indicates left lateral / left posterolateral AP.
    b. QRS transition (from negative to positive QRS) in V3 or later indicates right sided AP.
    c. Negative QRS in V1 and predominantly positive in V2 indicate septal AP.
2. Using the limb leads
    a. In the case of 1.a. Negative inferior leads indicate left posterolateral AP, while positive inferior leads indicate left lateral AP
    b. In the case of 1.c. Negative inferior leads indicate posterior septal AP; positive inferior leads indicate antero-septal AP while variable inferior leads positivity indicates mid-septal AP which includes para-Hisian AP.

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Negative inferior leads involve; three inferior leads with predominant S/QS or two leads with predominant S/QS and one lead with RS or rs. Positive inferior leads involve; three inferior leads with predominant R or two leads with predominant R and one lead with RS or rs.

Variable inferior leads positivity involves the situations in which inferior leads are not predominantly positive or predominantly negative and these include; one positive lead and two negative leads, two positive leads and one negative lead, one positive lead and two leads with RS or rs, one negative lead and two leads with RS or rs, or the three inferior leads with RS or rs.

EPS and Ablation: EPS was carried out using 4 intravenous lines through right and left femoral veins, one steerable Decapolar catheter with a 5mm inter electrode distance positioned in the coronary sinus, subsequently 3 Quadripolar catheters with a 5mm inter electrode distance positioned at high right atrium, His bundle and right ventricular apex. In case EPS showed the presence of left sided AP, right femoral artery was used to introduce the ablation catheter through retrograde aortic approach.

The presence and location of AP, in addition to the involvement of the AP in tachycardia were determined by a previously described method[8]. The surface ECG and intracardiac electrogram were displayed on a monitor using the EP Work Mate system (St. Jude Medical, Minnesota, USA). Localization of the position of ablation catheter was done using multiple fluoroscopy views.

Ablation was done using radiofrequency ablation catheters, either 4 mm tip non-irrigated ablation catheter with a target temperature 55ºC and a maximum power output of 35 Watt, or a 4mm tip irrigated catheter with a maximum power output of 35 Watt. If no loss in AP conduction was observed, the radiofrequency energy was discontinued after 15 seconds; however, if RF application was successful then the delivery of energy was continued for 90 seconds. If the AP conduction was still present, the catheter was repositioned, and the procedure was repeated.

Anatomic locations of AP: The AP locations were identified according to the successful ablation sites confirmed by multiple fluoroscopy views and were divided into 6 main regions (figure 2). The anatomic locations of the AP were assessed and recorded by two independent observers.

Electrocardiographic analysis: By using this algorithm criteria, localization of the site of an AP from surface ECG during sinus rhythm (speed 25 mm/min, sensitivity 0.1 millivolt/mm) were done by two independent observers one day prior to EPS and the results were reported, and eventually compared with the results of EPS on the next day.

Statistical Analysis: The data were analyzed by the computer using SPSS (Statistical Package for Social Science) version 22.0, and the results were presented in a tabular form. Sensitivity, specificity, positive predictive and negative predictive values were calculated.

RESULTS

The current study included 121 patients with manifested APs/ WPW syndrome. The population comprised of 73 males (60.3%) and 48 females (39.7%), with a mean age of 33 ± 12 years & range of 13- 69 years, as shown in table 1. There were six sites of the manifested accessory pathway with frequencies as per electrophysiological study, the left lateral AP being the most common one accounting for 35.5% (43 patients) cases and the posteroseptal AP being the second most common type found in 28.1% (34 patients) (table 2). The results obtained by applying this new stepwise algorithm to the patient's surface ECG, categorizing patients to six different anatomical locations of the manifested accessory pathway, are listed in table 3.

Validation of the results showed that the overall sensitivity of new algorithm in accurately detecting the site of AP in comparison to EPS was 94% and specificity was 98%, the positive predictive value was 90% and the negative predictive value was 99%. There were six sites of AP detected by EPS (left lateral, left posterolateral, anteroseptal, posteroseptal, mid septal, right sided), the sensitivity scores of the new algorithm were (91%, 100%, 100%, 91%, 100%, 81%, respectively), while the specificity values were (100%, 95%, 99%, 97%, 99%, 100%, respectively).

DISCUSSION

Localization of the accessory pathway site is a fundamental step prior to the electrophysiological study and radiofrequency ablation. It gives the electro-physiologist a piece of valuable information which guides the patient counseling concerning the risks and benefits of ablation. By localizing the AP, one can anticipate the possible complications such as AV block post ablation due to the proximity of AP to the conductive system, as well as the need for atrial septal puncture for left heart catheterization. In addition, it helps in preparing for ablation therapies such as cryoablation for septal accessory pathways or the need for special equipment for atrial septal puncture for left-sided APs.

The new algorithm has been developed depending on the general rules of ECG localization of Ventricular Tachycardia, because the ventricles are pre excited in both conditions [9,10]. Some of the ECG criteria for localization of AP in this study have been used previously [11]. However, a new algorithm has been proposed through this study. There were 6 sites of AP; one right free wall, 3 septal positions and 2 left sided APs. In this study, QRS vector and polarity were used predominantly for the localization rather than delta wave characteristics and this approach has been used in many studies [3,4,5].

The overall sensitivity of the new proposed algorithm was 94% with the individual sensitivity approaching 100% in some pathway location like left posterolateral, anteroseptal and mid-septal AP. The overall specificity was 98%, with individual specificity reaching 100% in the left lateral and right-sided accessory pathways. Similar results have been reported in Arruda algorithm with a sensitivity of 90% and specificity around 99% [1]. In Fox algorithm, the sensitivity was 90% [2] while Taguchi et al mentioned sensitivity and specificity of 94% and 98%, respectively [3].

LIMITATIONS

The sample size; especially, for midseptal and anteroseptal AP was small and patients with multiple APs were excluded from this study. In addition, the inherent weakness of any algorithm is the presence of intrinsic ECG abnormalities, variable fusion or cardiac rotation.

CONCLUSION

The new algorithm to localize the site of the AP from surface ECG can be easily applied with few steps needed in the assessment, showing overall good sensitivity and specificity.

Conflict of interest; The authors have no conflict of interest.

No financial support was received for this study

TABLES:

Table 1: *Distribution of Study population based on gender*

GENDER	Number	Percent
MALE	73	60.3%
FEMALE	48	39.7%
TOTAL	121	100%

Table 2: *Frequency of AP ablation site according to electrophysiological study*

AP Ablation site	Frequency	Percent
Left lateral	43	35.5
Left posterolateral	17	14
Anteroseptal	6	5.0
Posteroseptal	34	28.1
Mid septal	5	4.1
Right free wall	16	13.2
Total	121	100

Table 3: *Correlation between the predicted accessory pathway location (new algorithm) and the actual location based on the ablation site*

EP Ablation site		Predicted site according to the new algorithm algorithm						Validity of new			
Site	**Number**	**LL**	**LPL**	**AS**	**PS**	**MS**	**RS**	**Sensitivity**	**Specificity**	**PPV**	**NPV**
LL	43	39	3			1		91	100	100	96
LPL	17		17					100	95	77	100
AS	6			6				100	99	86	100
PS	34		2	1	31			91	97	91	97
MS	5					5		100	99	83	100
RS	16				3		13	81	100	100	97
TOTAL	121	39	22	7	34	6	13	94	98	90	99

(AS: anteroseptal, LL left lateral, LPL: left posterolateral, MS: mid-septal, NPV: negative predictive value, PPV: positive predictive value, PS: posteroseptal, RFW: right free wall.)

Figure 1

Stepwise algorithm to detect the site of the accessory pathway depending on the QRS vector on surface ECG.

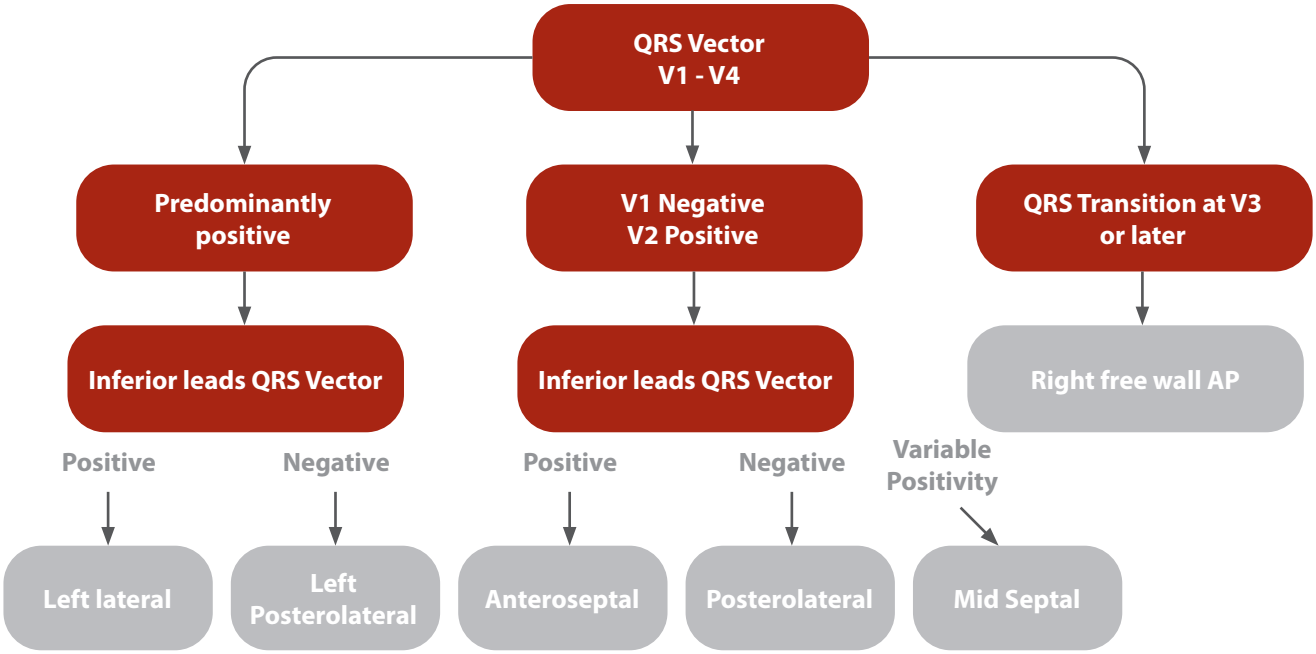
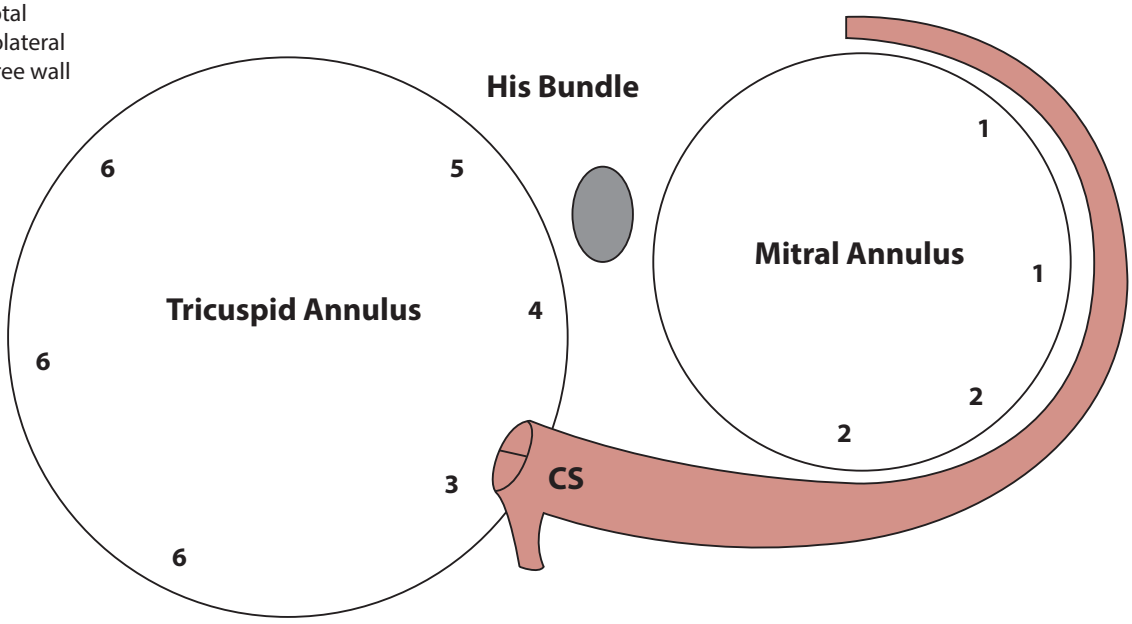


Figure 2

Diagrammatic representation of six different locations of accessory pathway is in patients with wolf parkinson white syndrome.

1. Left lateral
2. Left Posterolateral
3. Posterolateral
4. Midseptal
5. Posterolateral
6. Right free wall



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