МЕДИЦИНА НЕВІДКЛАДНИХ СТАНІВ®

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Assessment of a new ECG algorithm for identifying accessory pathway locations in WPW syndrome

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Abstract. ***Background.*** *In patients with Wolf-Parkinson-White (WPW) syndrome, localization of the site of accessory pathway using surface electrocardiography (ECG) is important step prior to any electrophysiological study and ablation. The purpose: to validate a new and simple stepwise algorithm to localize accessory pathway site from surface ECG during sinus rhythm.* ***Materials and methods.*** *It is prospective study enrolling patients with WPW syndrome scheduled for electrophysiological study and ablation in single center from January 2015 to February 2019. Surface ECG of patients with WPW syndrome one day prior to electrophysiological study was 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 was 121 patients, 73 males (60.3 %) and 48 females (39.7 %) with a mean age of 33 ± 12 years and 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 are 94 and 98 %, respectively, the positive and negative predictive values were 90 and 99 %. There were six sites of accessory pathways detected by electrophysiological study (left lateral, left inferolateral, anteroseptal, posteroseptal, midseptal and right-sided), the sensitivity of this algorithm for each accessory pathway site was 91, 100, 100, 91, 100, 81 %, respectively, while the specificity was 100, 95, 99, 97, 99, 100 %.* ***Conclusions.*** *This new algorithm to localize the site of the accessory pathway in patients with WPW syndrome from surface ECG is easily applied and has good sensitivity and specificity.*
Keyword: *accessory pathway; Wolf-Parkinson-White syndrome; electrophysiological study; preexcitation*

Introduction

Approximate localization of accessory pathway (AP) site using preexcitation 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 ECG [1–6].

There is no single published algorithm offer exceptionally high sensitivity and or specificity for all accessory pathways' locations [6, 7].

The purpose of the study was to validate a new and simple stepwise algorithm to localize AP site from surface ECG during sinus rhythm.

Materials and methods

Study population. The study population consisted of consecutive patients underwent successful catheter ablation for manifest AP at Nassiriya Heart Centre from January 2015 through February 2019.

Patients with multiple antegradely conducting AP and those with structural heart disease in addition to those with failed ablation were excluded.

All anti arrhythmic drugs were discontinued for at least 5 half-lives before the study.

Study design. This algorithm was developed over two years since 2012 and applied at Nassiriya Heart Centre (in addition to the already existing algorithms) and this study was designed for prospective assessment and validation of this algorithm.

To localize the site of the accessory pathway, the ECG criteria adopted in this study are as the following (Fig. 1):

1. Using the QRS vector in chest leads:

a) predominantly positive V1-V6 indicate left lateral/left posterolateral AP;

b) QRS transition at V3 or later indicate right-sided AP;

c) negative QRS in V1 and predominantly positive in V2 indicate septal AP.

2. Using limb leads:

a) in the case of 1a, negative inferior leads indicate left posterolateral AP, while positive inferior leads indicate left lateral AP;

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b) in the case of 1c, negative inferior leads indicate posterior septal AP, positive inferior leads indicate anteroseptal AP, while variable positivity indicates midseptal which include para-Hisian AP;

c) in 1b, positivity of inferior leads detect at which site of the right free wall the AP is located.

EPS and ablation. EPS started using 4 intravenous lines through right and left femoral veins, one steerable decapolar catheter with a 5-millimeter inter electrode distance positioned in the coronary sinus, then 3 quadripolar catheters with a 5-millimeter inter electrode distance positioned at high right atrium, his and right ventricular apex. In case EPS proved 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 EP-WorkMate system (St. Jude Medical, Minnesota, USA).

Localization of the position of ablation catheter was done using multiple fluoroscopy views.

Ablation were done using radiofrequency ablation catheters, either 4 millimeters tip non irrigated ablation catheter with a target temperature 55 °C and a maximum power output of 35 Watt, or a 4-millimeter tip irrigated catheter with a maximum power output of 35 Watt.

If there was no loss of AP conduction, the radiofrequency energy was discontinued after 15 seconds, if successful, continue 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 (Fig. 2). The anatomic location of the AP were assessed 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 mV/mm) were done by two independent observers one day prior to EPS and the results were reported, then the results were compared with the results of EPS next day.

Statistical analysis. The data were analyzed in the computer by using Statistical Package for Social Science version 22, and the results were presented into simple self-explanatory tabulation. Sensitivity, specificity, positive predictive and negative predictive value were calculated.

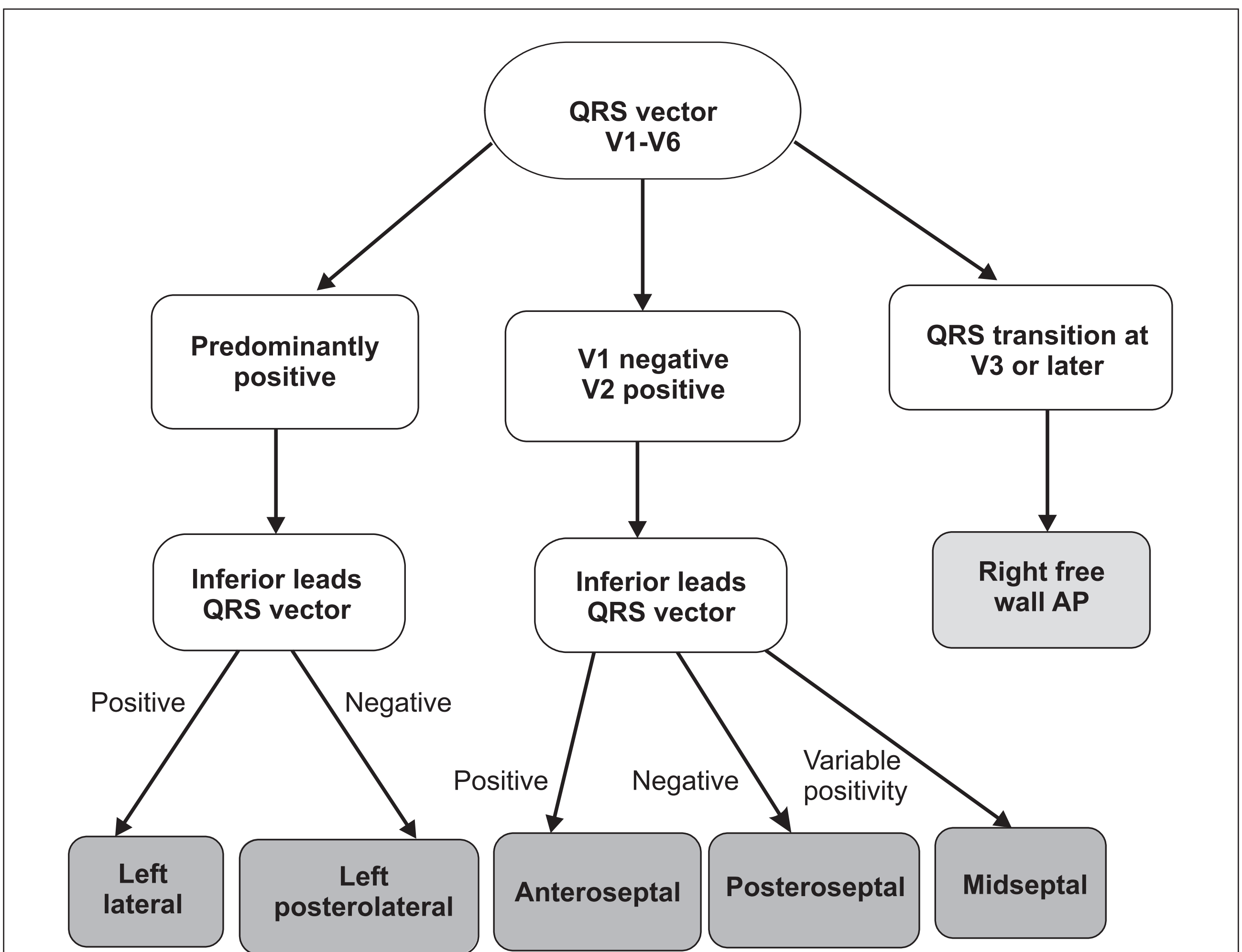

Figure 1. Stepwise algorithm to detect the site of the accessory pathway depending on the QRS vector

Results

This is study include 121 patients with manifested accessory pathways Wolf Parkinson (WPW) syndrome, 73 males (60.3 %) and 48 females (39.7 %), with a mean age of 33 ± 12 years and range of 13–69 years, as shown in Table 1.

Table 1. Gender frequency of study patients

Gender	No.	%
Male	73	60.3
Female	48	39.7
Total	121	100

There were six sites of the manifested accessory pathway with their frequencies according to electrophysiological study, the left lateral AP being the most common one and account for 35.5 % (43 patients) with the posteroseptal AP the second most common 28.1 % (34 patients) (Table 2).

Table 2. Accessory pathways' location according to electrophysiological study

AP ablation site	No.	%
Left lateral	43	35.5
Left inferolateral	17	14
Anteroseptal	6	5.0
Posteroseptal	34	28.1
Midseptal	5	4.1
Right free wall	16	13.2
Total	121	100

By applying the new stepwise algorithm to the patient's surface ECG, categorizing patients to six different anatomical locations of the manifested accessory pathway, the result was listed in Table 3.

Validation of the results shows that overall sensitivity of this algorithm in accurately detecting the site of AP in comparison to EPS is 94 % and specificity 98 %, the positive predictive value 90 % and the negative predictive value 99 %.

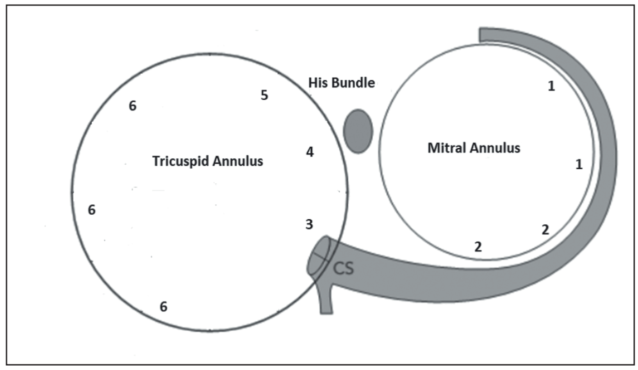

Figure 2. Diagrammatic representation of 6 different locations of accessory pathways in patients with Wolf-Parkinson-White syndrome: 1 — left anterolateral/left lateral; 2 — left posterolateral/left posterior; 3 — posteroseptal; 4 — midseptal; 5 — anteroseptal; 6 — right free wall

There were six sites of AP detected by EPS (left lateral, left posterolateral, anteroseptal, posteroseptal, midseptal, right-sided), the sensitivities of our new algorithm were (91, 100, 100, 91, 100, 81 % respectively), while the specificities were (100, 95, 99, 97, 99, 100 %).

Discussion

Localization of accessory pathway site is a fundamental step prior to the electrophysiological study and radiofrequency ablation. It gives the electrophysiologist a piece of valuable information which guides the patient counseling concerning the risks and benefits of ablation, so that one can anticipate the possible complications like AV block post ablation due to the proximity of the accessory pathway to the conductive system, as well as the need for atrial septal puncture of left heart catheterization.

In addition, it helps in preparing for ablation 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 [9, 10], because the ventricles are preexcited in both conditions.

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						Accuracy parameters			
Site	No.	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**

Notes: LL — left lateral; LPL — left posterolateral; AS — anteroseptal; PS — posteroseptal; MS — midseptal; RS — right-sided; PPV — positive predictive value; NPV — negative predictive value.

Some of the ECG criteria for localization of AP in this study has been used previously [11]. However, the whole algorithm is new.

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 localization rather than delta wave characteristics and this approach has been used in many studies [3–5].

The overall sensitivity of the new proposed algorithm is 94 % with individual sensitivity approaching 100 % in some pathway location like left posterolateral, anteroseptal and midseptal AP. While the overall specificity is 98 %, with individual specificity reaching 100 % in left lateral and right-sided accessory pathways.

Arruda algorithm reported a sensitivity of 90 % and specificity around 99 % [1]. In Fox algorithm, the sensitivity was 90 % [2]. In addition, Taguchi et al. mentioned a sensitivity and specificity about 94 % and respectively of 98 % [3].

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

Conclusions

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

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Оцінка нового алгоритму ЕКГ для визначення локалізації додаткових провідних шляхів при синдромі ВПВ

Резюме. ***Актуальність.*** У пацієнтів із синдромом Вольфа — Паркінсона — Вайта (ВПВ) визначення розташування додаткових провідних шляхів за допомогою поверхневої електрокардіографії (ЕКГ) є важливим кроком перед будь-яким електрофізіологічним дослідженням та абляцією. ***Мета:*** валідувати новий і простий покроковий алгоритм для визначення локалізації додаткового провідного шляху за поверхневої ЕКГ під час синусового ритму. ***Матеріали та методи.*** У цьому проспективному дослідженні взяли участь пацієнти із синдромом ВПВ, яким було заплановано електрофізіологічне дослідження та абляцію в одному центрі з січня 2015 року по лютий 2019 року. Поверхневі ЕКГ, зроблені за день до електрофізіологічного дослідження, використовували для застосування цього алгоритму з метою локалізації додаткового провідного шляху та порівняння отриманих результатів із даними електрофізіологічного дослідження наступного дня. ***Результати.*** Загальна кількість пацієнтів — 121, серед них 73 чоловіки (60,3 %) і 48 жінок (39,7 %), середній вік яких дорівнював 33 ± 12 (діапазон 13–69) років. Загальні чутливість та специфічність алгоритму у виявленні додаткового провідного шляху з використанням місця успішної абляції як референтного тесту становлять 94 та 98 % відповідно, а прогностична значущість позитивного та негативного результатів — 90 та 99 %. За допомогою електрофізіологічного дослідження було виявлено шість локалізацій додаткових провідних шляхів (лівий боковий, лівий задньобоковий, передньоперегородковий, задньоперегородковий, середньоперегородковий та правий), чутливість алгоритму для кожного місця розташування становила відповідно 91, 100, 100, 91, 100, 81 %, тоді як специфічність — 100, 95, 99, 97, 99, 100 %. ***Висновки.*** Новий алгоритм для визначення додаткового провідного шляху в пацієнтів із синдромом ВПВ за поверхневою ЕКГ є простим у застосуванні та характеризується високими чутливістю і специфічністю.

Ключові слова: додатковий провідний шлях; синдром Вольфа — Паркінсона — Вайта; електрофізіологічне дослідження; передчасне збудження