Original Article

LOCALIZATION OF ACCESSORY PATHWAYS ACCORDING TO AP FITZPATRICK ECG CRITERIA IN PATENTS WITH WOLFF-PARKINSON-WHITE SYNDROME IN OUR POPULATION

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ABSTRACT

Objectives: The objective of this prospective study was to localize the accessory pathways (AP) in patients with Wolff Parkinson White syndrome (WPW) using algorithm laid down by AP Fitzpatrick, in our population.

Materials and Methods: 500 consecutive patients with the most pre-excited 12 lead ECG in sinus rhythm visiting emergency department were analyzed. Delta wave frontal plane vector, polarity in V1, height in leads I, II and Ill and sum of delta waves polarities in II, lII and aVF. R wave size in leads I, II, Ill, V1; R/S ratio in leads I, aVL, V1; S wave size in V1 and QRS axis and duration; QRS horizontal plane transition zone were the main EGG variables used to localize the accessory pathway. The most discriminative characteristics were combined to form the following steps. Step 1, location of the transition lead (R and S waves are equiphasic) in the chest leads and R>S wave by > or < 1mV, this divides the pathways into right and left sided. Step 2, sum of delta waves polarities in leads II, Ill and aVF, this divides the pathways into Septal or lateral locations.

Results: Among 500 patients, 409(81.8%) patients had WPW syndrome while 91(18.2%) patients had WPW pattern. Mean age of study population was 34.23±12.5 years. There were 327(65.4%) males and 173(34.6%) females with a male to female ratio of 3:1. Three hundred (60%) patients had right sided accessory pathways while 190(38%) had left sided AP. Among right sided AP Right posteroseptal pathway was the most common location 87(28.8%) comprising (17.7%) of total population. Left antero-lateral pathway was the most common location not only among left sided pathways 95(50%) but also in total study population (19.4%).

Conclusion: The AP Fitzpatrick ECG criteria for localization of the accessory pathways on surface ECG is an excellent non invasive method for determination of the site of accessory pathway with very high sensitivity, specificity and predictive accuracy. It is an excellent tool before planning invasive electrophysiological study in WPW syndrome.

Keywords: Wolff-Parkinson-White syndrome, accessory pathways, electrocardiography.

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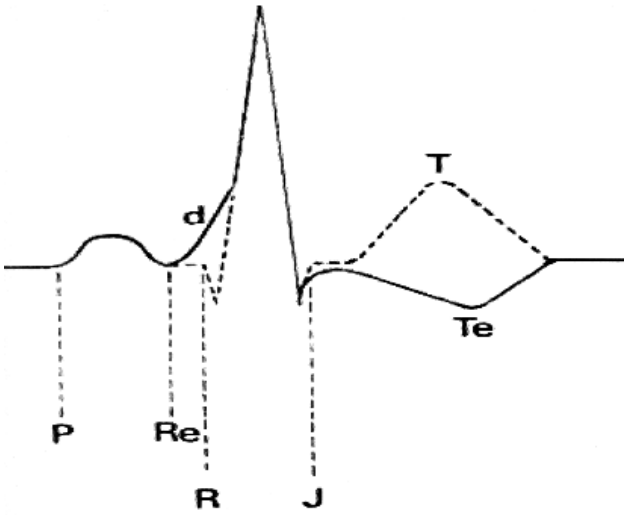
INTRODUCTION

An electrocardiographic (ECG) syndrome first fully described by Wolf-Parkinson & White in 1930.[1] It is the commonest variety of Pre-excitation Syndrome associated with an accessory AV connection, called Kent Bundle or Paladino tracts. The surface ECG is characterized by, a shortened PR interval for age (<120 milliseconds in adults), prolonged QRS duration for age (>120 milliseconds), with a slurred slow rising onset of the R wave upstroke (Delta Wave) consistent with pre-excitation of the base of the heart. Secondary ST and T wave changes which

are directed opposite to the major Delta wave and QRS vector. Figure 1. The clinical Supraventricular tachycardia (SVT) which is narrow QRS orthodromic

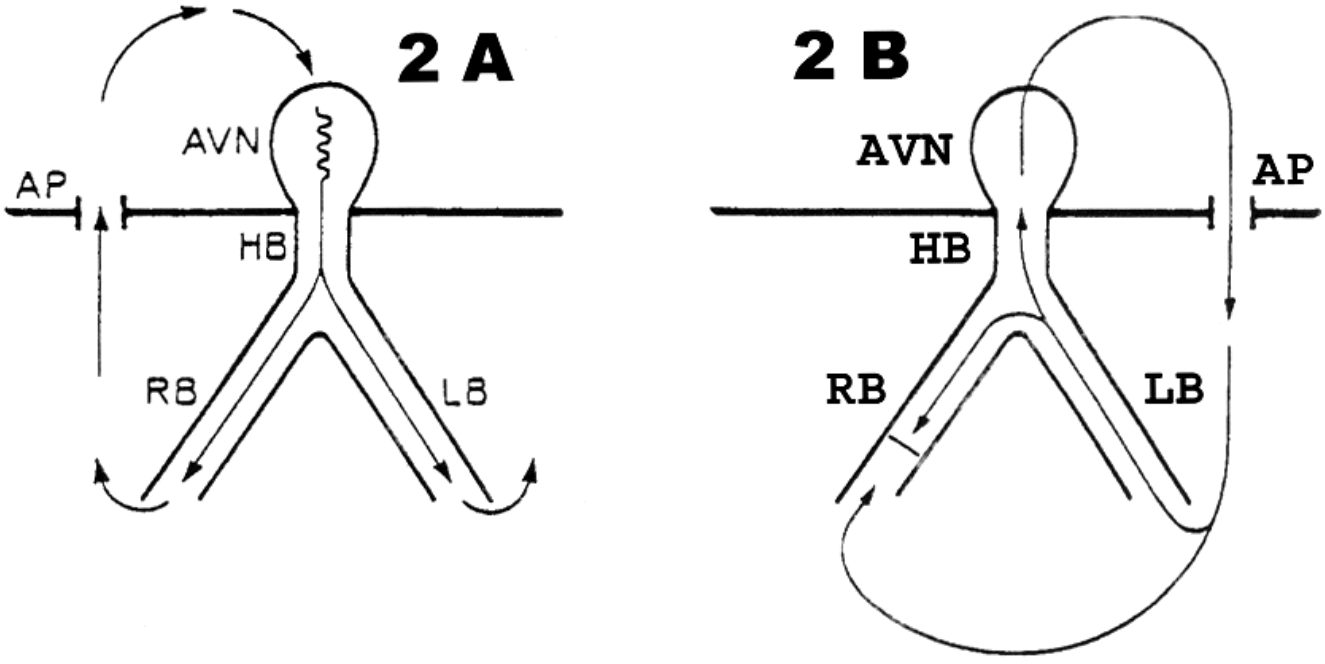
Figure 1. Solid line indicates ventricular depolarization via AP and dotted line indicates ventricular depolarization via normal conduction system.



tachycardia (NQRST), using Atrio-ventricular node (AVN) for ante-grade and accessory pathway (AP) for retro-grade conduction is the most common SVT (70%). Ten percent of the patients present with wide QRS antidromic tachycardia, in which AVN is used for retro grade and AP for ante-grade conduction. Figures 2. Sixteen percent of the patients suffering from WPW syndrome present in emergency room (ER) in atrial fibrillation and these patients are at very high risk of sudden cardiac death (SCD) as they can easily go in to ventricular tachycardia (VT) and ventricular fibrillation (VF).[2]

Four percent present in atrial flutter. Thirty percent of the patients have concealed AP with only retrogradely conducting AP. Incidence of the syndrome is 1 in 1000 live births. Thirty two to forty six (32-46) percent have congenital heart disease and the commonest congenital heart disease associated is Ebstein's anomaly.[3] Ten to twenty percent of cases undergoing surgical or radiofrequency (RF) ablation has multiple accessory pathways.[4] Males are affected more than females. Rosenbaum et al[5] in 1945 used the surface ECG QRS morphology to divide WPW in to Type A (large R wave in V1) and Type B (S or QR in V1) but this simplest scheme was inadequate.

Figure 2. (A) Diagrammatic presentation of orthodromic re-entry, using conduction over AVN in antegrade and AP in retrograde fashion. (B) diagrammatic presentation of antidromic re-entry, using conduction over AP in antegrade and AVN in retrograde fashion.



Galliger et al[6] described the ten locations of AP around the mitral and tricuspid annuli on the basis of surgically derived ECG algorithms at Duke University on the basis of delta wave polarity.

However, the extremities of these locations were not defined anatomically, and were very difficult to relate to fluoroscopic landmarks. Later Yaun et al[7] and Milstein et al[8] developed an algorithm with four anatomical locations of AP along the atrioventicular grove (right free wall, left free wall, anteroseptal and posteroseptal) on the basis of surgically ablated AP. This algorithm carried a 71% sensitivity and 91% specificity. In this case posteroseptal pathways were classified as one group, rather than in to right posteroseptal, left posteroseptal and midseptal pathways.

Chiang et al[9] gave stepwise electrocardiographic algorithm for localization of accessory pathways in WPW syndrome from analysis of delta wave and R/S ratio using delta wave polarity in V1 in the initial 60 milliseconds, which has its own limitations.

In mid eighties catheter ablation techniques especially radiofrequency catheter ablation methods have revolutionized the anatomical location of atrioventricular accessory connections as it demands precise pathway location because of the microscopic size of the target tissue and small lesion size. A typical radiofrequency lesion produced by a 4 mm tip catheter and 25-35 Watts of energy may be of the order of only 4-12 mm in diameter and 3 mm deep.[10]

On the basis of large study of RF ablation of accessory pathways in WPW syndrome, AP Fitzpatrick described eight anatomical locations of pathways using fluoroscopic landmarks, obtained in 45° right anterior oblique and 40° left anterior oblique projections. Five of these accessory pathways are located on the right side along the tricuspid valve annulus and three left sided are located along the mitral valve annulus.[11] These are named as:

1. Right anteroseptal (RAS)
2. Right midseptal (RMS)
3. Right posteroseptal (RPS)
4. Right anterolateral (RAL)
5. Right posterolateral (RPL)
6. Left anterolateral (LAL)
7. Left posterolateral (LPL)
8. Left posteroseptal (LPS)

The most pre-excited 12 lead ECG is used to analyze the location of accessory pathways and certain ECG variables are used for step wise discriminate analysis. Following important ECG variables should be used to localize the pathways.

Delta wave frontal plane vector

Delta wave polarity in V1.

Delta wave height in leads I, II and Ill.

Sum of the Delta wave polarities in leads II, Ill and aVF.

The height or the polarity of the delta wave is measured on the surface ECG in the first 40 msec of QRS complex from the end of P wave. On the basis of this it is ISOELECTRIC, if it is on the baseline or deflected above or below the baseline but comes back before the onset of QRS complex. Figure 3. POSITIVE, if it is above the baseline and NEGATIVE, if it is below the baseline. Figure 4.

QRS duration is significantly increased in right sided than the left sided accessory pathways (145±17, range 100-180 msec; versus 131±15, range 110-164 msec). $p<0.001$

QRS horizontal plane transition zone

Transition zone is measured by relative amplitude of R to S wave in chest leads. If R wave is dominant in V1, transition is scored 0, if R and S waves equiphasic, then that lead is transition lead and if it is between two leads then half score is allotted. Figure 5.

Algorithms for defining location of Accessory Pathways producing Pre-excitation. Table 1

A) Right Sided Versus Left Sided

The most significant variable is horizontal QRS transition in chest leads ($p<0.000l$). If QRS transition is at or before V1 or dominant R wave in V1, then it is Left sided pathway. If transition is after V2, it is right sided pathway. If the transition is at V2 or between V1 and V2, then measure the amplitude of R-wave and S wave in lead I. If R>S wave in lead I by 1 mV it is right sided otherwise it will be left sided accessory pathway.

B) Left Anterolateral vs. Left Posterior

The most significant variable is delta wave polarities in the inferior leads ($p<0.0001$) and the ratio of the R

Figure 3. Isoelectric Delta wave.

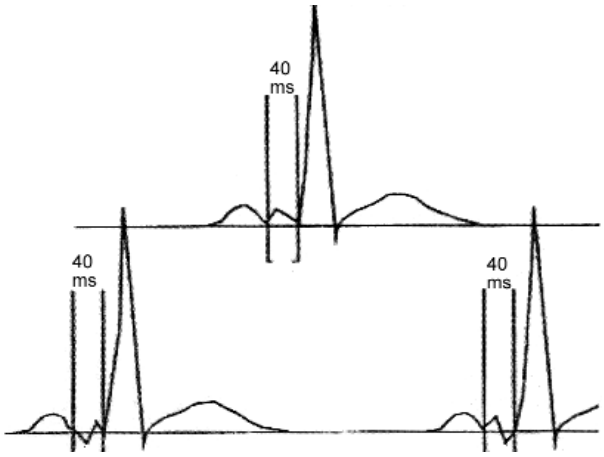
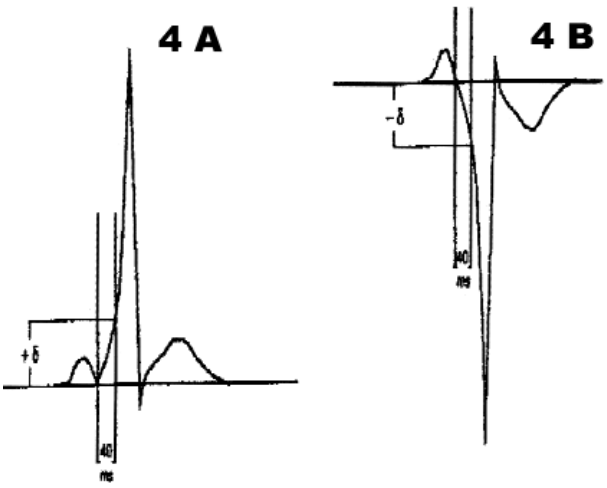


Figure 4. Positive and negative in first 40 m sec R wave size in leads I, II, III and V1. R wave to S wave ratio in leads I, aVL and V1, QRS axis and duration. 4 A= positive delta wave. 4 B= negative delta wave.

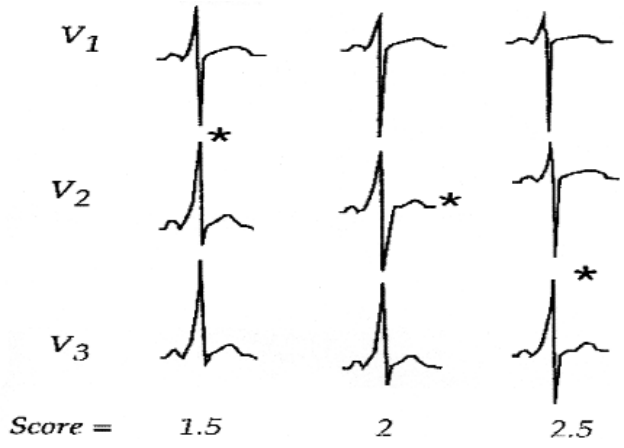


wave to the S wave in lead aVL ($p<0.001$). Two or more than two positive delta wave in inferior leads or S wave larger than R wave in aVL indicates anterolateral location of the accessory pathway. (100% sensitivity and specificity).

C) Left Posterolateral vs. Left Posteroseptal

The sum of the inferior delta wave polarities and the amplitude of R wave to S wave in lead I are the best ECG variables to differentiate the two sites ($p<0.05$). If the R wave is greater than S wave in lead 1 by 0.8 mV and delta waves are negative in inferior leads, the pathway is located at left posteroseptal site otherwise it will be left posterolateral location of the accessory pathway.

Figure 5. Scheme showing the method of deriving the horizontal QRS transition. Four typical transition leads are shown for chest leads V1 to V3. QRS transition is based on the relative amplitude of R to S wave in chest leads. A dominant R wave in any lead indicates QRS transition before that lead, and a dominant S wave indicates QRS transition after that lead. Equiphasic R and S waves indicate transition at that lead. The asterisk (*) indicates the location of QRS transition, and the score assigned.



D) Right Septal vs. Right Free Wall

QRS transition ($p<0.0001$) is the most significant variable and delta wave amplitude in lead II ($p<0.005$) can assist to discriminate where the first variable is equivocal. QRS transition at or before V3 indicates a septal location, whereas transition at or after V4 indicates free wall location (Anterolateral or poserolateral) of the accessory pathways. If the transition is between V3 & V4 then look for the amplitude of delta wave in lead II; if it is equal or more than 1 mV then septal location otherwise lateral location (97% sensitivity & 95% specificity).

E) Right Anterolateral vs. Right Postero Lateral

Delta wave frontal plane axis is the most significant variable ($p<0.0001$) and if this is equivocal the R wave amplitude in lead III caries a p value of <0.0005. if the delta wave frontal plane axis is equal or more than zero, then the pathway location is at anterolateral site otherwise it is at posterolateral location (92% sensitivity, 100% specificity).

F) Right Anteroseptal vs. Right Posteroseptal vs. Right Mid Septal

Delta wave polarities in leads II, Ill and aVF is the most significant variable ($p<0.0001$).

Table 1. Localization of 10 accessory pathways on the basis of delta wave polarity on the surface ECG.

	1	11	111	aVR	aVL	aVF	V1	V2	V3	V4	V5	V6
1	+	+	+(±)	-	±(+)	+	±	±	+(±)	+	+	+
2	+	+	-(±)	-	+(±)	±(-)	±	+(±)	+(±)	+	+	+
3	+	± (-)	-	-	+	-(±)	±	±	±	+	+	+
4	+	-	-	-	+	-	±(+)	±	+	+	+	+
5	+	-	-	-(+)	+	-	±	+	+	+	+	+
6	+	-	-	-	+	-	+	+	+	+	+	+
7	+	-	-	±(+)	+	-	+	+	+	+	+	-(±)
8	- (±)	±	±	±(+)	-(±)	±	+	+	+	+	+(±)	-(±)
9	- (±)	±	+	-	-(±)	+	+	+	+	+	+	+
10	+	+	+(±)	-	±	+	±(+)	+	+	+	+	+

±=Delta wave is isoelectric; +=Delta wave is positive; -= Delta wave is negative

If it is greater than +1, the pathway is located at anteroseptal region; if it is less than 1 then it is posteroseptal and if it is 0 or +1 or -1 then it is located at midseptal site (sensitivity and specificity is between 85-100%).

METHODS

Patients of either sex and age visiting Cardiology Department of Mayo hospital and Punjab Institute of Cardiology Lahore with WPW syndrome or WPW pattern were included in this study. 12 lead ECG was recorded in sinus rhythm at a paper speed of 25 mm/sec on a standard grid thermal paper with normal standardization and evaluated from 2 independent observers. The most pre excited QRS complex in each of the 12 lead was defined as the one with the shortest interval from the start of the P wave to the initiation of the delta wave in that lead, and the duration of the delta wave in that lead was defined as the portion from the initial deflection to the point at which it joined the main QRS deflection. On the basis of these parameters and algorithm mentioned in the introduction of this article laid down by AP Fitzpatrick, the ECG of the 500 consecutive patients visiting Cardiology Deportment Mayo Hospital Lahore and Punjab Institute of cardiology Lahore between June 2003 to June 2007 with ECG manifest WPW were analyzed.

RESULTS

Mean age of the study population was 34.23±12.5 years and there were 327(65.4%) male and 173(34.6%) females with approximate male to female ratio of 3:1.

Four hundred and nine(81.8%) patients presented with WPW syndrome i.e. with history of tachycardia and only 91(18.2%) patients had incidental ECG finding of WPW pattern.

Three hundred (60%) patients had characteristic ECG findings consistent with right sided accessory pathways,190(38%) had finding consistent with left sided accessory pathways and remaining 10(2%) had inconclusive findings.

Among right sided accessory pathways posteroseptal was the most common location as it was found in 87 patients contributing 28.8% among right sided and 17.7% among total number of patients. 63 Patients (21.35%, 12.9%) had right anterolateral and only 41 patients had right midseptal accessory pathways (13.6% 8.3%). Table 2.

Among left sided accessory pathways 95 patients had anterolateral location while 69 and 26 patients had posterolateral and posteroseptal locations respectively contributing 50%, 36.4% and 13.6%

among left sided pathways and 19.4%, 14.2% and 5.3% among total number of patients respectively. Table 3.

Table 2. Distribution of Right sided accessory pathways

RIGHT SIDED ACCESSORY PATHWAYS	No. OF PATIENTS	% in RAP n=300	% in Total n=490
RAL	63	21.3	12.9
RPL	50	16.6	10.2
RAS	59	19.7	12.0
RMS	40	13.6	8.3
RPS	87	28.8	17.7

RAP=Right accessory pathway; RAL=Right anterolateral; RPL=Right posterolateral; RAS=Right anteroseptal; RMS=Right midseptal; RPS=Right posteroseptal.

Table 3. Distribution of Left sided accessory pathways

LEFT SIDED ACCESSORY PATHWAYS	No. OF PATIENTS	% in LAP n=190	% in Total n=490
LAL	95	50.0	19.4
LPL	69	36.4	14.2
LPS	26	13.6	5.3

LAP=Left accessory pathway; LAL=Left anterolateral; LPL=Left posterolateral; LPS=Left posteroseptal.

DISCUSSION

By a comprehensive analysis of delta wave polarity and R/S ratio to get transition lead in chest leads on the basis of criteria in the algorithm given by AP Fitzpatrick, the location of AP can easily be judged on the surface ECG in sinus rhythm in WPW syndrome in over 90% of cases accurately. The algorithm was entirely based on the results from radiofrequency ablation of these pathways and was featured by its easiness to be applied. Previous ECG criteria for localization of accessory pathways have been far from satisfaction due to the following reasons:

1. The polarity of the delta wave was not defined in detail.
2. The portion of the initial segment of the pre-excited QRS that could best represent the delta wave during sinus rhythm was not determined.
3. Some criteria divided the accessory pathway location into only 4 or 5 regions, which does not correlate with exact location during radiofrequency ablation.
4. Several criteria utilize only delta wave polarity during maximal pre-excitation for discrimination but atrial pacing is needed for this purpose. The new algorithm developed by AP Fitzpatrick used in this study has clear cut stepwise fashion, analyzing the precordial R/S ratio and the well defined delta wave polarity in only 4 ECG leads during sinus rhythm based solely on the results from radiofrequency catheter ablation.

CONCLUSIONS

In this study it is very clear that left free wall accessory pathways, including both anterolateral and posterolateral (20% + 14.5% = 34.5%) are the most common site of location among all the described locations. Posteroseptal is the commonest among the septal locations and also among right sided accessory pathways (17.3% versus 5.5% and 28.8%). This surface ECG flow chart is an excellent non invasive method of localizing the accessory pathways with very high sensitivity, specificity and predictive accuracy. It is an excellent tool before planning invasive electrophysiological study in WPW syndrome.

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