Accuracy and Limitations of Published Algorithms Using the Twelve-Lead Electrocardiogram to Localize Overt Atrioventricular Accessory Pathways

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Accessory Pathway Localization. ***Introduction:*** **The purpose of this study was to evaluate the accuracy and limitations of published algorithms using the 12-lead ECG to localize AV accessory pathways (APs).**

Methods and Results: **The 11 relevant algorithms found in the literature (MEDLINE database and major scientific sessions) were tested on a series of 266 consecutive patients who successfully underwent radiofrequency catheter ablation of a single overt AV AP. The positive predictive values (PPV) of the algorithms in applicable patients were significantly lower for algorithms with > 6 accessory location sites (40.6% ± 10.9% vs 61.2% ± 8.0%; P < 0.03) and show a tendency for algorithms not relying on delta wave polarity but on QRS polarity only (36.6% ± 11.2% vs 52.3% ± 13.1%; P = 0.09). The PPV in applicable patients is related to the AP location (P < 0.001) and ranked from the highest to the lowest as follows: left lateral (mean PPV = 86.3%), posteroseptal (mean PPV = 65.2%), right anteroseptal (mean PPV = 45.2%), and right posterolateral (mean PPV = 23.4%).**

Conclusion: **Our study suggests that the accuracy of algorithms relying on the 12-lead ECG depends on AP locations as defined in the algorithms and on the number of AP sites. The accuracy tends to be lower when delta wave polarity is not included in the algorithm's architecture. This should be considered when using these algorithms or when building new ones.**

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electrocardiography, accessory pathway, Wolff-Parkinson-White syndrome, algorithm, radiofrequency catheter ablation

Introduction

Radiofrequency (RF) catheter ablation has been used widely for about a decade to cure patients with Wolff-Parkinson-White (WPW) syndrome[1-4] and even now is the principal nonpharmacologic therapeutic option in symptomatic patients. This syndrome relies on the presence of an AV accessory pathway (AP), depicted by delta wave polarities on the 12-lead ECG, which correlate with the pathway's ventricular insertion site. The location of this AP should be determined precisely by endocavitary mapping during the ablation procedure to minimize the lesions created by RF energy, which are small and well defined. Relying on the noninvasive identification of the pathway location has a def-

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inite clinical interest in guiding the endocavitary mapping and forecasting specific techniques and materials for the ablation procedure (transseptal puncture, special catheters).

Many studies dealing with noninvasive localization of the AP have been published ever since the early report by Rosenbaum et al.[5] Some authors describe algorithms using the 12-lead surface ECG.[6-11] Other authors designed their algorithm with a database of electrograms, field testing them with another series of patients.[12-15] To our knowledge, there are no reports on the accuracy and limitations of published algorithms based on a large and independent 12-lead ECG database. Such was the aim of this study.

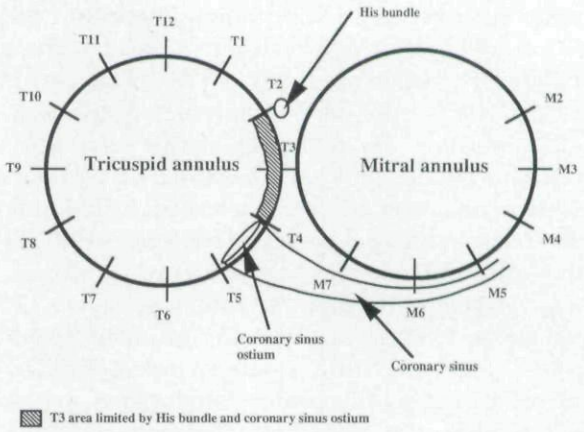

Figure 1. *Accessory pathway label sites along the mitral and tricuspid annuli. Schema correspond to the mitral and tricuspid annuli viewed under a 45° left anterior oblique fluoroscopic projection.*

Methods

Patients

The study population consists of 266 consecutive patients with the WPW syndrome (186 men; mean age 34.5 ± 14.7 years) who successfully underwent RF catheter ablation of a single overt AV AP.

Patients were included in the study when they fulfilled all of the following criteria: (1) presence of a normal preprocedural transthoracic echocardiogram; (2) presence of cardiac symptoms related only to the tachyarrhythmic episodes; (3) presence of a manifest ventricular preexcitation and a QRS width ≥ 110 msec on the 12-lead ECG at admission; (4) withdrawal on admission of all antiarrhythmic drugs for at least five half-lives (with the exception of amiodarone); (5) presence of a single overt AV AP assessed by an electrophysiologic study; (6) successful RF catheter ablation of the AP confirmed by the disappearance of both anterograde and retrograde conduction obtained with the same RF application; and (7) patient consent.

AP Location

Location of the AP was defined by the site were RF energy application successfully abolished conduction. In this article, the ablation site label refers to the mitral or tricuspid annulus, with the 12 o'clock position as the uppermost cephalad location (Fig. 1) using the 45° left anterior oblique fluoroscopic projection. The location of a given AP corresponds to the closest label, with the exception of the T3 site whose borders are precisely defined by the catheter recording the His-bundle electrogram and that marking the coronary sinus ostium.

Electrocardiogram

A 12-lead surface ECG was recorded 1 day to 1 month prior to the ablation procedure with the patient resting and in sinus rhythm (three leads recorded simultaneously, 25 mm/sec paper speed, 10 mm/mV gain, filter band settings from 0.05 to 150 Hz). When several 12-lead ECGs were available, the one that exhibited the largest preexcitation pattern was selected for further analysis. Two independent observers, unaware of the AP location, reviewed the 266 ECGs to determine and measure, on every derivation: (1) polarity of the delta wave, (2) amplitude of the delta wave, (3) delta wave axis (frontal plane), (4) QRS duration, (5) polarity of the QRS complex, (6) amplitude of all components of the QRS complex, (7) QRS axis (frontal plane), and (8) morphology of the entire QRS complex (rS pattern, QS pattern . . .). The observers then compared their notes and a consensus was reached, forming a consolidated database.

In the literature, three classifications document delta wave polarities.[14-16] Appropriate definitions were used by the reviewers with each specific algorithm.

Literature

The MEDLINE database (United States National Library of Medicine, http://*www.ncbi.nlm.*

nih.gov) searched for publications concerning the localization of AV APs using 12-lead surface ECGs. The following key words were used: ECG, criteria, AP, WPW syndrome, localization, and algorithm. By reviewing theses references, relevant articles published since the early report by Rosenbaum et al.[5] were identified. In addition, abstracts published between 1985 and 1997 at the following meetings were screened: (1) American Heart Association Scientific Sessions, (2) American College of Cardiology Annual Scientific Session, (3) North American Society of Cardiac Pacing and Electrophysiology Annual Scientific Sessions, and (4) Congress of the European Society of Cardiology.

The selected publications fulfilled the following criteria: (1) the development of an algorithm was based on a series of patients, with review articles excluded; (2) the algorithm was based only on the QRS and/or delta wave analysis of a standard 12-lead ECG obtained during sinus rhythm in patients with an overt AV AP; (3) $>$ 50 patients were included to develop the algorithm; (4) the AP location was ascertained by a successful surgical or catheter ablation, or by a precise electrophysiologic mapping; and (5) the algorithm did not exclude, a priori, any locations along the mitral or tricuspid annulus.

The most recent algorithm was considered for evaluation in this study when different algorithms were published by the same authors.

Test Procedure

All selected algorithms found in the literature were tested on our series of 266 patients by observers unaware of the location of the AP.

To compare the published algorithms, each accessory position and label was translated among the various standards used and our own (defined in Fig. 1).

Definitions were as follows: (1) the applicability of an algorithm is the percentage of ECGs obtained from our patient pool that could be classified by the algorithm; and (2) the positive predictive value (PPV) of an algorithm is the percentage of APs from our series that could be correctly localized by the algorithm.

Statistical Analysis

Noncontinuous variables were compared using the Chi-square test. The Mann-Whitney rank sum test was used to compare groups. $P < 0.05$ was considered statistically significant.

Results

Clinical Data

Figure 2 illustrates the AP localization distributed in our patient population. APs were more prevalent along the mitral annulus (M2-M7; 162/

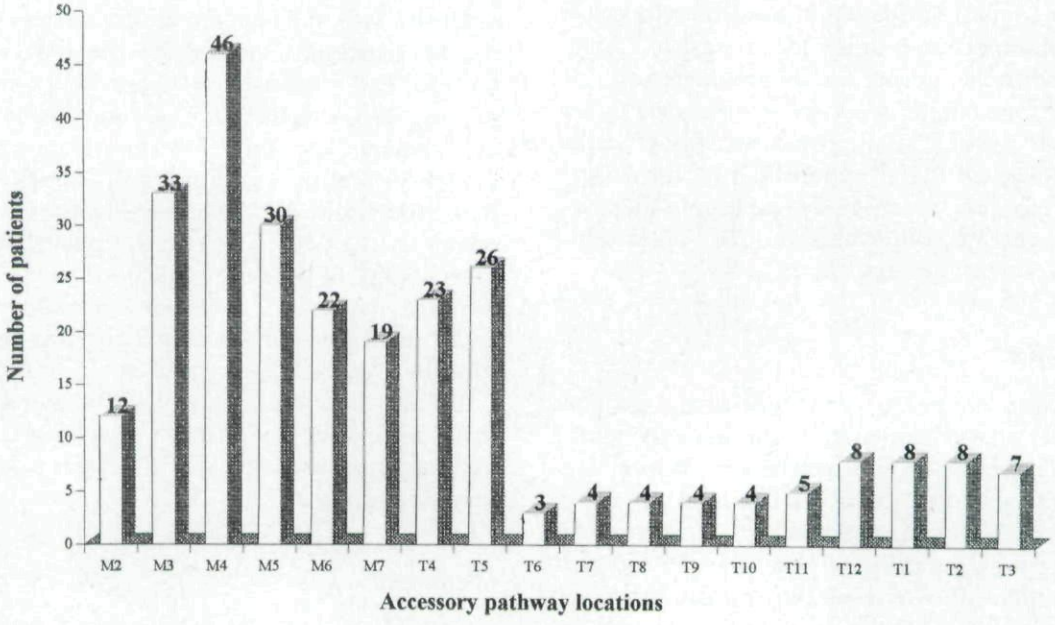

Figure 2. *Distribution of accessory pathway localizations in our patient population.*

266 [60.9%]). The right-sided APs (T1-T12; 104/266 [39.1%]) were predominantly found on T4 and T5 (49/266 [18.4%]), sites usually referred to as right posteroseptal in the literature.

Literature Algorithms

Forty-one publications (references 5 to 45) report on methods for localizing the AP in patients with WPW syndrome. Of these 41 studies, only 11 were evaluated here.[6-9,14-16,37,40,43,44] The methodologic characteristics of these 11 publications are listed in Table 1.

The remaining publications were excluded because of the following criteria: (1) the proposed algorithm[12,13,19-22,24,27-30] was not based on a defined set of patients, or new algorithms were not presented; (2) development of the algorithm[31] was not based exclusively on a standard 12-lead ECG analysis; (3) < 50 patients[5,18,26] were retained to develop the algorithm; (4) specific locations along the mitral and/or tricuspid annulus were a priori disregarded[23,25,32-34,41,42,45] by the algorithm; or (5) the algorithm described in the publication[10,11,17,35,36,38,39] has been revised or updated more recently.

Methodologic Characteristics of the Selected Algorithms

Inspection of the 11 algorithms highlights a great variability in the number of AP locations (Table 1). These can be separated into two groups: articles differentiating > 6 sites (n = 7) and articles differentiating < 6 sites (n = 4). Spanning 20 years, the ECG features selected to build the algorithms oscillate. In particular, delta wave polarity was not included in three publications, and the number of derivations used varied from 3 to 12.

Algorithm Testing

The AP locations defined in each publication were matched with the definitions described in Figure 1, based on information given in the publication and by interviewing the authors (for reference 44). Table 2 normalizes the literature classifications and labels in relation to the position of the AP along the tricuspid or mitral annulus in the 45° left anterior oblique projection.

Table 3 shows the applicability and PPV of the 11 algorithms tested on our 266 patients. These values were calculated with the AP location defined in the literature and with the corresponding extended segments, which encompass an area defined in the reference publication (Table 2) plus one contiguous normalized position at each end.

As shown in Table 3, four algorithms offer 100% applicability,[9,14-16] with only two[6,8] obtaining an applicability < 80%.

In applicable patients, the PPV of the algo-

TABLE 1
Methodologic Characteristics of the 11 Publications Selected from the Literature

Year	Authors	No. of Patients to Build the Algorithm	No. of AP Location Sites Defined by the Algorithm	Method Determining AP Location	Twelve-Lead ECG Features Used to Build the Algorithm				
					QRS Polarity	Delta Wave Polarity	QRS Morphology	Amplitude or Duration Criteria	No. of Leads Used
1978	Gallagher (6)	163*	10	Surg ablation (n = 83*) EP mapping (n = 80*)	No	Yes	No	No	12
1987	Milstein (7)	141	4	Surg ablation (n = 97) EP mapping (n = 44)	Yes†	Yes	Yes	Yes	9
1987	Lindsay (8)	66	5	Surg ablation (n = 45) EP mapping (n = 21)	Yes	Yes	No	No	10
1990	Frank (9)	61	5	Surg ablation	Yes	Yes	No	No	12
1994	Fitzpatrick (16)	93	8	RF ablation	Yes	Yes	Yes	Yes	9
1994	Xie (37)	60	9	RF ablation	Yes	No	Yes	Yes	9
1995	D'Avila (40)	140	8	RF ablation	Yes	No	Yes	No	5
1995	Chiang (14)	182	9	RF ablation	Yes	Yes	No	No	4
1996	Iturralde (43)	102	5	RF ablation	Yes	No	No	Yes	3
1996	Farré (44)	97	9	RF ablation	No	Yes	Yes	No	5
1998	Arruda (15)	135	10	RF ablation	Yes	Yes	No	No	5

*Personal communication from Dr. John J. Gallagher.
†Used to determine QRS axis only.
AP = accessory pathway; EP = electrophysiologic; RF = radiofrequency; Surg = surgical.

TABLE 2
Literature Classifications and Labels of Accessory Pathway Locations in Relation to the Position of the Accessory Pathway along the Tricuspid or Mitral Annulus in the 45° Left Anterior Oblique Projection

Normalized Annulus Positions	M2	M3	M4	M5	M6	M7	T4	T5	T6	T7	T8	T9	T10	T11	T12	T1	T2	T3
Gallagher (6)	LAPS	LA	LL	LL	LP	LPPS	RPS	RPS	RP	RP	RL	RL	RL	RA	RAPS	RAPS	—	—
Milstein (7)	LL	LL	LL	LL	LL	PS	PS	PS	RL	RL	RL	RL	RL	AS	AS	AS	—	—
Lindsay (8)	LL	LL	LL	LP	LP	PS	PS	PS	RFW	RFW	RFW	RFW	RFW	RFW	AS	AS	AS	—
Frank (9)	LL	LL	LL	LL	LL	LP	RP	RP	RL	RL	RL	RL	RL	RL	RAS	RAS	RAS	—
Fitzpatrick (16)	LAL	LAL	LPL	LPL	LPL	LPS	RPS	RPS	RPL	RPL	RPL	RPL	RAL	RAL	RAL	RAL	RAS	RMS
Xie (37)	LAL	LAL	LPL	LPL	LP	LPS	RPS	RPS	RP	RP	RL	RL	RL	RA	RA	RA	RAS	MS
D'Avila (40)	LL	LP	LP	LPS	LPS	PS	PS	PS	RPS	RPS	RL	RL	RL	AS	AS	AS	AS	MS
Chiang (14)	LAL	LL	LPL	LPL	LP	LPS	RPS	RPS	RP	RPL	RPL	RL	RL	RAL	RAL	RA	RAS	MS
Iturralde (43)	LAS	LAS	LIP	LIP	LIP	LIP	RIP	RIP	RIP	RIP	RIP	RA	RA	RA	RA	RAS	RAS	—
Farré (44)	LL*	LL*	LL*	LP*	LP*	LPS*	RPS* CSPS*	RPS* CSPS*	RP*	RP*	RP*	RAL*	RAL*	RAL*	RAL*	RAS*	RAS*	RMS*
Arruda (15)	LAL	LL	LL	LPL	LP	PSMA	PSTA CSOs	PSTA CSOs	RP	RPL	RL	RL	RL	RAL	RA	AS RAPS	AS RAPS	MSTA

Abbreviations here are defined in their original articles and correlate to the normalized mitral and tricuspid annulus positions.
*Personal communication from Dr. J. Farré.

rithms range from 29.8% to 67.6%. After regrouping them, the algorithms with < 6 defined segments offer an overall combined PPV of 60.7%, which represents 594 confirmed hits in 979 found, the remaining 385 allocated to a different pathway location according to our ablation procedure. Using the Mann-Whitney rank sum test, this predictability is significantly higher ($P < 0.03$) when compared with the compilation from algorithms involving > 6 segments, with, in applicable patients, a combined PPV of 41.8% obtained from 668 confirmed hits of a possible 1,596 tests. Using an extended segment definition, PPV in applicable patients increases in all algorithms, although more markedly for approaches with > 6 defined segments. Their combined PPV thus progresses from 41.8% to 67.7% (1,081 correct hits on 1,596 tests), whereas the combined PPV evolves from 60.7% to 75.8% (742 hits on 979 tests) in algorithms with < 6 defined segments.

There is no correlation between the ECG features listed in Table 1 and the PPV in applicable patients or applicability with the algorithms tested, although there is a tendency to a lower PPV (36.9% [278/753]) in algorithms not relying on the delta wave polarity compared with a combined PPV of 54.0% (984/1,822) when the delta wave polarity is built into the algorithm ($P = 0.09$ using the Mann-Whitney rank sum test). When extended segments were considered, however, the PPV in applicable patients of algorithms not relying on the delta wave polarity was significantly lower ($P < 0.03$) compared with the others (combined PPV of 59.4% [447/753] and 75.5% [1,376/1822], respectively).

No clear relation was found between global PPV and either ECG features or number of segments included (Table 3). A combined global PPV of 55.8% for algorithms relying on < 6 segments can be opposed to those designs with greater speciation and a lower combined global PPV of 35.9% (although removing reference 6, which has a particularly low applicability, increases the global PPV to 40.4%). This identifies a tendency with $P = 0.06$ by the Mann-Whitney rank sum test.

Despite the great variability in the number of segments differentiated among the authors, four areas can be collated and analyzed comparatively. These subgroups are listed in Table 4. For comparison, some flexibility in defining cutoff (vertical lines in Table 2) was necessary for Lindsay, Frank, Fitzpatrick, and Farré at the T9

TABLE 3
Applicability and Positive Predictive Value of the Literature Algorithms

		Positive Predictive Value in Applicable Patients		Global Positive Predictive Value	
	Applicability	**Defined Segments**	**Extended Segments**	**Defined Segments**	**Extended Segments**
Gallagher (6)	28.6% (76/266)	30.3% (23/76)	72.4% (55/76)	8.7% (23/266)	20.7% (55/266)
Milstein (7)	98.9% (263/266)	62.7% (165/263)	73.4% (193/263)	62.0% (165/266)	72.6% (193/266)
Lindsay (8)	70.7% (188/266)	67.6% (127/188)	85.1% (160/188)	47.7% (127/266)	60.2% (160/266)
Frank (9)	100% (266/266)	64.7% (172/266)	77.1% (205/266)	64.7% (172/266)	77.1% (205/266)
Fitzpatrick (16)	100% (266/266)	42.1% (112/266)	67.3% (179/266)	42.1% (112/266)	67.3% (179/266)
Xie (37)	88.3% (235/266)	29.8% (70/235)	52.8% (124/235)	26.3% (70/266)	46.6% (124/266)
D'Avila (40)	96.2% (256/266)	30.5% (78/256)	54.3% (139/256)	29.3% (78/266)	52.3% (139/266)
Chiang (14)	100% (266/266)	43.2% (115/266)	76.3% (203/266)	43.2% (115/266)	76.3% (203/266)
Iturralde (43)	98.5% (262/266)	49.6% (130/262)	70.2% (184/262)	48.9% (130/266)	69.2% (184/266)
Farré (44)	86.8% (231/266)	51.1% (118/231)	77.1% (178/231)	44.4% (118/266)	66.9% (178/266)
Arruda (15)	100% (266/266)	57.1% (152/266)	76.3% (203/266)	57.1% (152/266)	76.3% (203/266)

to T12 border. In Iturralde's article, the border zones were markedly different as compared with the other authors; thus, his algorithm was not considered in Table 4.

For all algorithms tested, there is a clear correlation between the PPV in applicable patients and the area collated: M2-M6 not only represents the majority of the APs but also the highest PPV in all algorithms tested, ranging from 82.7% to 97.6% with a combined PPV of 86.3%, whereas the T6-T10 area accounts for 19 ECGs only in our database and the lowest combined PPV at 23.4% (range 2.6% to 60%). Sorting in order of decreasing PPVs finds M2-M6 with a combined PPV of 86.3%, followed by M7 and T4-T5 (combined PPV = 62.5%), T11-T3 (combined PPV = 45.2%), and then T6-T10 (combined PPV = 23.4%).

A comparative analysis between the various algorithms tested on the four defined segments in Table 4 results in a nonsignificant variability for M2-M6 (PPV varies from 82.7% to 97.6%; $P = 0.08$ by Chi-square analysis), whereas the three remaining "zones" exhibit significant variations, with $P < 0.003$.

Figures 3, 4, and 5 are examples of three 12-lead ECGs with different percentages of success in the identification of the AP location by the 11 algorithms.

Discussion

In this study, we investigated the limitations and accuracy of published algorithms with the aim to determine the precise localization of AV APs with only the surface ECG as a predictive

TABLE 4
Positive Predictive Value in Applicable Patients of Published Algorithms to Localize the Accessory Pathway in Relation to the Position of the Accessory Pathway along the Tricuspid or Mitral Annulus in the 45° Left Anterior Oblique Projection

	M2-M6 (N = 143)†	**M7 or T4-T5 (N = 68)†**	**T6-T10* (N = 19)†**	**T11-T3* (N = 36)†**	**P Value**
Gallagher (6)	97.6% (41/42)	60.0% (12/20)	100% (1/1)	46.2% (6/13)	< 0.001
Milstein (7)	93.7% (104/111)	56.0% (42/75)	17.8% (8/45)	34.4% (11/32)	< 0.001
Lindsay (8)	85.8% (97/113)	82.1% (32/39)	27.8% (10/36)	NP	< 0.001
Frank (9)	85.5% (130/152)	60.3% (44/73)	36.0% (9/25)	25.0% (4/16)	< 0.001
Fitzpatrick (16)	87.8% (115/131)	70.4% (38/54)	60.0% (3/5)	44.7% (34/76)	< 0.001
Xie (37)	82.7% (110/133)	51.4% (18/35)	2.6% (1/38)	13.8% (4/29)	< 0.001
D'Avila (40)	83.4% (126/151)	92.3% (12/13)	22.8% (13/57)	45.7% (16/35)	< 0.001
Chiang (14)	82.9% (131/158)	74.1% (40/54)	47.1% (8/17)	64.9% (24/37)	< 0.001
Iturralde (43)	NC	NC	NC	NC	
Farré (44)	89.4% (126/141)	37.5% (6/16)	33.3% (2/6)	51.5% (35/68)	< 0.001
Arruda (15)	84.6% (132/156)	71.7% (33/46)	16.7% (3/18)	54.3% (25/46)	< 0.001
Average	86.3% (1112/1288)	65.2% (277/425)	23.4% (58/248)	45.2% (159/352)	

*Some flexibility in the definition of these areas was accepted for references 8, 9, 16, and 44, with the transition between T9-T10 for Fitzpatrick, between T11-T12 for Lindsay and Frank, and between T8-T9 for Farré.
†Number of ECGs in our database.
NC = not calculated; NP = no patients.

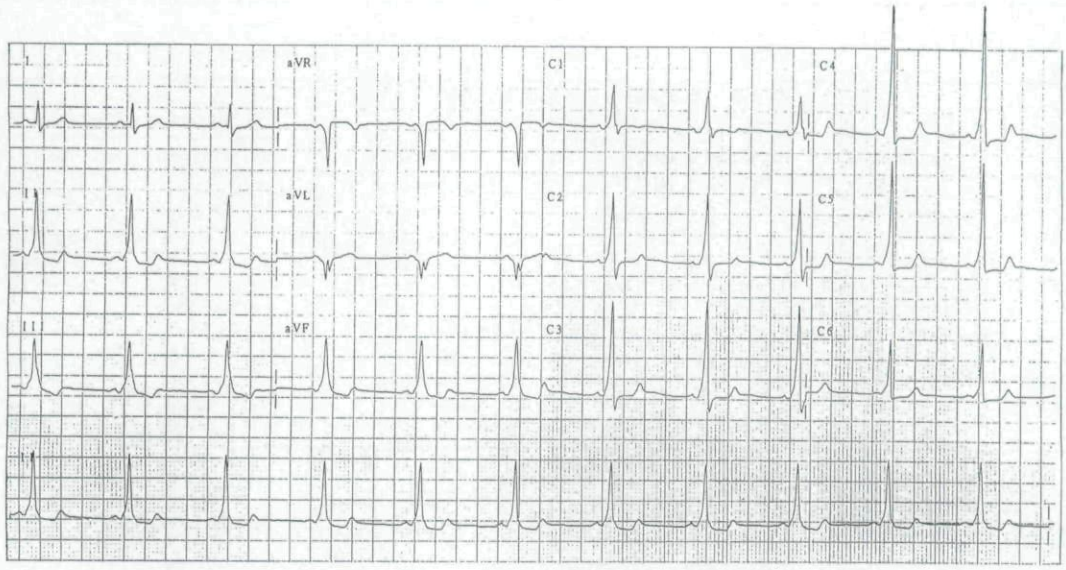

Figure 3. *Twelve-lead ECG of a patient with an accessory pathway localized at the M3 site. All algorithms correctly identified the position of this accessory pathway.*

tool. A threefold conclusion can be drawn from our study: (1) the PPV of published algorithms is greater when little segmentation of the mitral and tricuspid annuli is performed, albeit at the expense of less precision in the AP localization; (2) there is a lower PPV with extended segment localization when delta wave polarity is omitted from the algorithm's architecture; and (3) the accuracy of the algorithms is related to the accessory location with the greatest predictive power attained on the M2-M6 segment (overall combined PPV of 86.3%) and the lowest predictive power for APs on the T6-T10 segment (overall combined PPV of 23.4%).

An applicability of 100%, or absolute ability to attribute an AP localization (irrespective of whether it is correct) in our entire test population, is achieved in only four algorithms.[9,14-16] The only algorithm with an extremely low applicability is Gallagher's algorithm, which relies on a restrictive decisional architecture, classification requiring an appropriate delta wave morphology

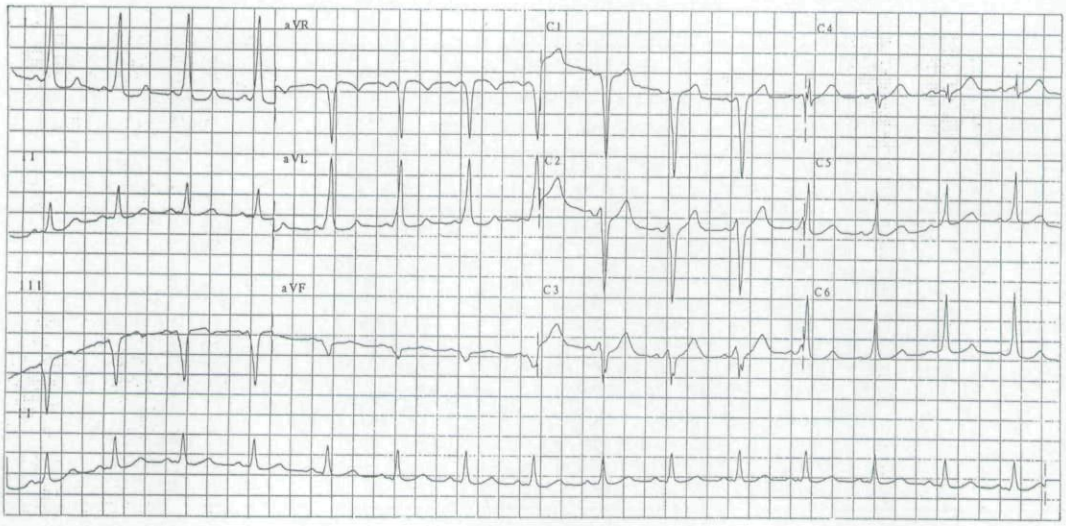

Figure 4. *Twelve-lead ECG of a patient with an accessory pathway localized at the T9 site. Only five algorithms*[7,14,16,40,44] *correctly identified the position of this accessory pathway.*

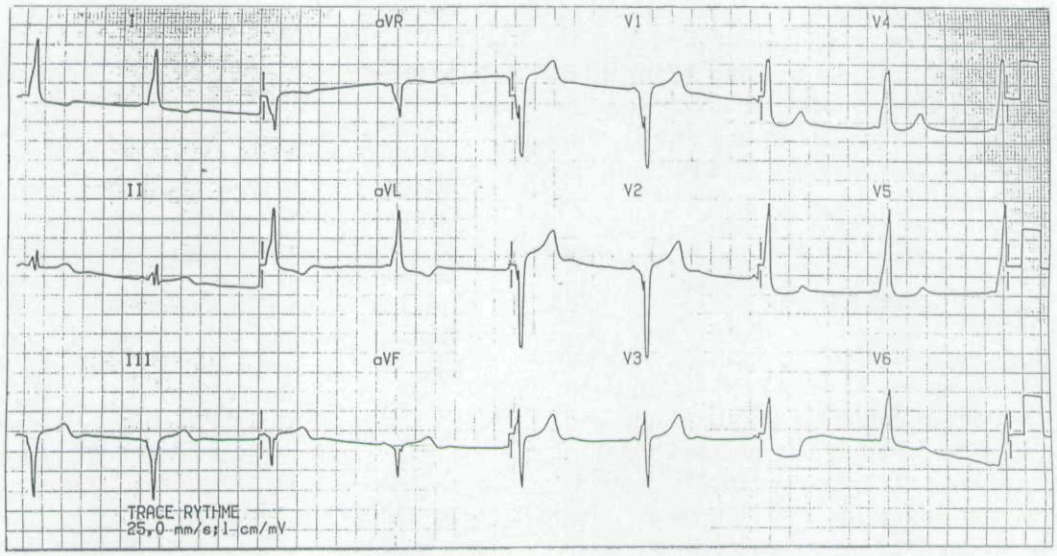

Figure 5. *Twelve-lead ECG of a patient with an accessory pathway localized at the T1 site. None of the algorithms correctly identified the position of this accessory pathway.*

for all 12 leads simultaneously: an ECG not fulfilling all criteria (91 possible patterns) would fall out of the scheme, thereby decreasing the applicability. The other algorithms are mostly based on a discriminating stepwise analysis, with the intermediary results either positive or negative and orienting the subsequent steps. With this approach, the applicability is higher, with each step classifying an ECG to fit either one or the other branch of the scheme. Such a process yields very few indeterminate results.

Calculating the PPV with segments correctly allocated and then with "extended" segmentation underlines the importance of the border zone in localizing an AP site: the PPV and the global PPV increase significantly when some flexibility is allowed in comparing the cutoff zones between algorithms. Fitzpatrick's posterolateral area illustrates this well: an AP on border sites T6 and T10 would be expected to present significantly different ECG features, yet each would resemble their adjacent respective T5 and T11 areas, which are topologically far away, in the right posteroseptal and anterolateral areas. Increasing the number of sites forcibly increases the number of borders, thus decreasing the PPV with increasing number of sites as calculated in Table 3. As a consequence, the greater impact of the extended segment concept is seen for algorithms displaying high speciation, by extending the annulus segmentation to adjacent sites, resulting in a decreased number of sites and thus increased PPV.

Comparing various algorithms necessitates a standardized AP site localization around the mitral and tricuspid annuli. This was made possible with the data shown in Table 4. All algorithms test well in identifying the M2-M6 segment; a great variability exists for the other locations.

Limitations

The small number of algorithms tested constitute a limitation of this study. Testing all published algorithms perhaps would have helped to identify other relationships between the PPV and the different characteristics of the algorithms. Of the 23 "general" algorithms based on original work, it seemed important to test only one approach per group to avoid redundancy. Algorithms constructed with < 50 patients were avoided to limit the error margins associated with small populations, where the reliability is decreased further by the distribution of poorly represented AP locations, such as right lateral and anteroseptal.

The results comparing the true AP localization and that predicted by the test algorithm are expressed as a "combined PPV," a percentage expressing the number of hits divided by the total number of tests performed. A similar "overall" calculation for the applicability and global PPV

was retained, as this weighs each approach and is more significant than an average of the 11 algorithms tested, which would truncate information as to the total number of tests performed. A 100% PPV with one patient at one localization should not weigh as much as 70% PPV with 50 patients.

Conclusions

Our study suggests that the accuracy of algorithms relying on the 12-lead ECG depends on the AP locations as defined in the algorithms and on the number of AP sites. The accuracy tends to be lower when delta wave polarity is not included in the algorithm's architecture. This should be considered when using these algorithms or when building new ones. It should be recommended to use a standardized method (such as that used here) to define AP location and avoid possible misinterpretation of algorithms.

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