

Comparison of the accuracy of three algorithms in predicting accessory pathways among adult Wolff-Parkinson-White syndrome patients

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- After the introduction of catheter ablation of atrio-ventricular accessory pathways in Wolff-Parkinson-White syndrome, to facilitate the planned ablation and minimize catheter-related injury, predicting the AP was required. Localization of APs can be anywhere around the atrio-ventricular annuli; left- or right-sided or within the septum or a rare possibility of Mahaim fibers [1].

- Several algorithms with varying degrees of complexity and accuracy based on the analysis of QRS and delta wave morphology on the 12-lead electrocardiogram have been proposed for accurate localization of APs. Although the 12-lead ECG is an easy, non-invasive tool to determine the localization of APs and guide ablation procedures, employed algorithms are complex to put in practice and remember, in addition; delta wave polarity is difficult to assess.

- Previous studies have reported inconsistent and inaccurate results with adult ECG algorithms, in particular in the pediatric patients [2-4].

- Therefore, in this study we evaluated the accuracy of three published algorithms in predicting APs and their limitations regarding the site of the APs and presence of delta wave polarity in the algorithm design.

Patient selection

- At initial analysis, 229 consecutive patients who underwent radiofrequency ablation for WPW syndrome at our institution from 2000 to 2014 were retrospectively analysed. Patients under the age of 18, with congenital heart defects, multiple APs, concealed pathways, and unsuccessful RFA were excluded. Finally, a total of 207 patients (mean age 36.4 ± 12.5 , 58.5% male) were included in the study and analyzed to compare the predictive accuracy of the algorithms.

Algorithms

- Three algorithms were selected to compare the predictive accuracy for AP localizations. Of the three algorithms, two included delta wave polarity in the algorithm design (Chiang, Arruda) and one did not include delta wave polarity in its design (d'Avila) were selected for comparing the accuracy of predicting APs [5-6].

- Chiang et al. developed an algorithm based on a retrospective analysis of ECGs of 182 adults who underwent RFA that was then tested prospectively among 187 adult patients. In their study they applied a stepwise approach starting with the determining R/S ratio in lead V₂; delta wave polarity in leads III, V₁ and aVF, and then R/S ratio in V₁ to localize APs. They described 13 regions around the tricuspid and mitral valves and reported 93% accuracy that provided better results with left-sided APs.
- Arruda et al. developed an algorithm by analyzing retrospectively ECGs of 135 adult WPW syndrome patients, which was then tested prospectively in 121 adult patients. The algorithm based on determining the delta wave polarity in leads I, II, aVF and V₁ and followed by the analyses of R/S ratio in leads III and V₁. They described 13 locations around the tricuspid and mitral valves including the locations within or adjacent to coronary sinus and reported 90% sensitivity and 99% specificity, best for **anteroseptal, midseptal and ventricular venous branches- or coronary sinus-related** APs.
- d'Avila et al. analysed retrospectively 140 patients who underwent RFA and evaluated the QRS polarity in leads V₁, III, aVL, II and V₂ to determine the AP localization. They described **8 locations** and reported 92 % predictive accuracy with their algorithm.

Accessory pathway analysis

- Two cardiologists experienced in electrophysiology, analysed patients' ECGs according to the algorithms described by Chiang et al., d'Avila et al. and Arruda et al. The exact localization of the AP was determined by biplane fluoroscopy at the time of catheter ablation [7].

- In case of an algorithm predicted more than one AP, it was accepted a match if the exact AP was included in any predicted sites. Incorrect locations that are adjacent to the exact location were accepted as adjacent site prediction (i.e., Chiang predicted left posterior/left posterolateral locations, but the actual successful site of catheter ablation was left lateral). If the predicted AP site was contralateral to the actual AP location (i.e., right vs. left), it was accepted as contralateral site prediction.

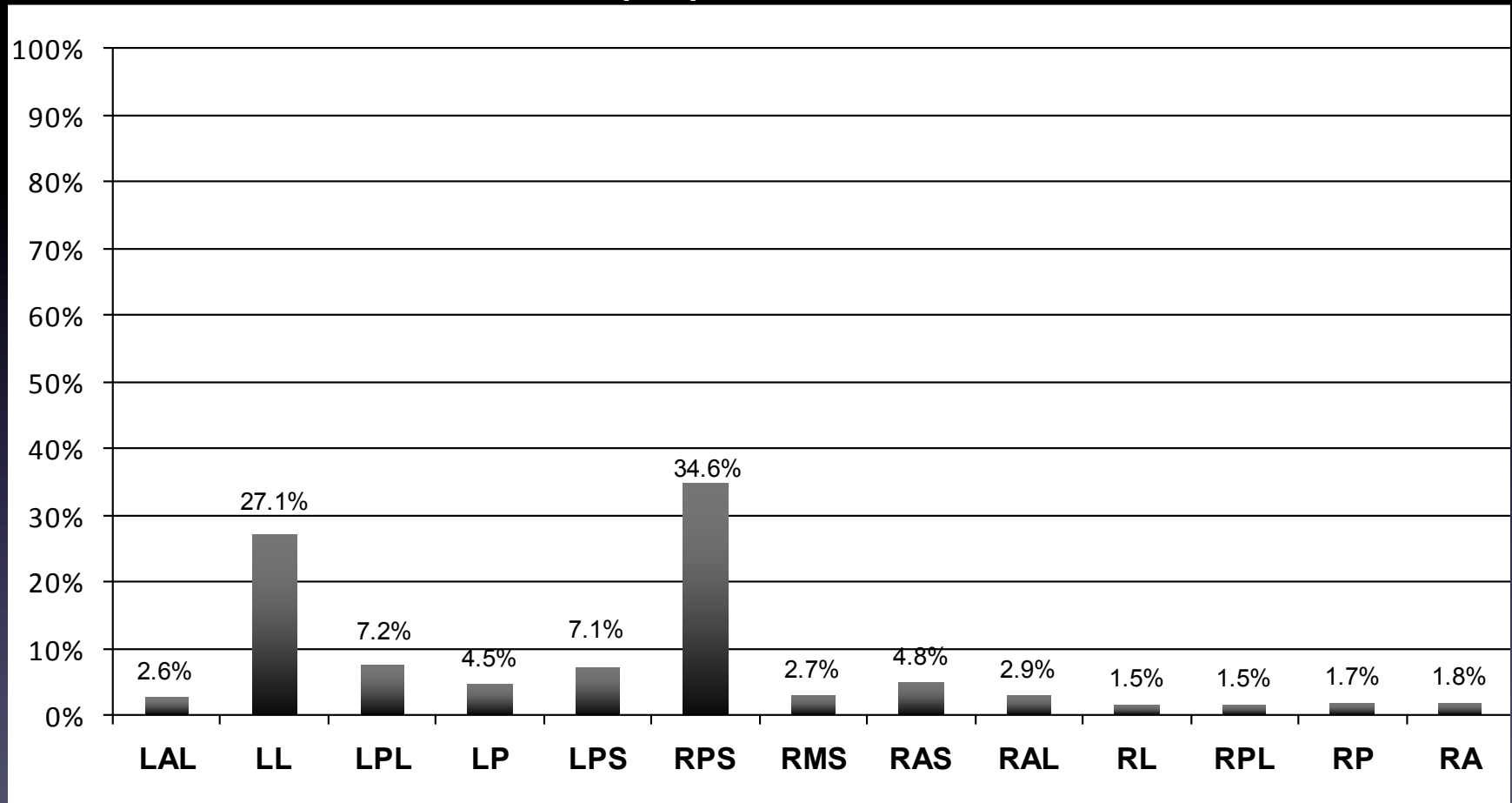
- All investigators analysed ECGs using two different algorithms. Also, each investigator repeated the ECG analyses with the same algorithm. All of the algorithms were compared according to the percentage of exact matches, adjacent and contralateral sites matches.

Statistical analysis

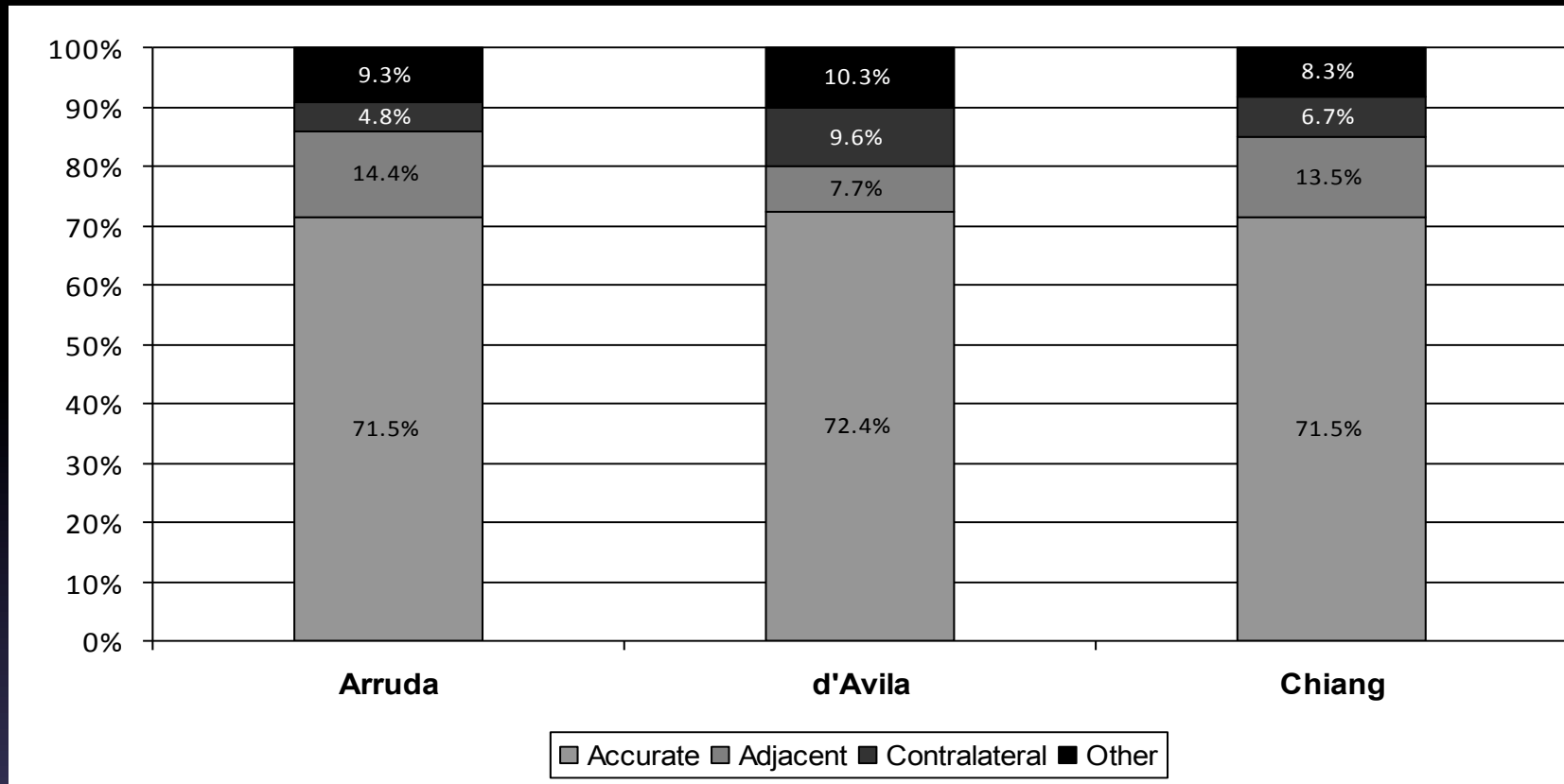
- Whether the differences in prevalence of match cases regarding for accessory pathway location between algorithms were statistically significant or not was evaluated by McNemar test. Coefficients of Kappa were calculated for determining the levels of both intra- and also inter-observer agreement. Kappa values over 0.75 as excellent, 0.40 to 0.75 and below 0.40 were considered as fair to good and poor; respectively. Degrees of agreement between AP location and each other algorithm regarding for distribution of localizations were also determined by calculating coefficients of kappa. Determining the best algorithm that discriminates cases regarding for AP localization was evaluated by Multiple Logistic Regression analyses. Odds ratios, 95% confidence intervals and wald statistics were also calculated for each algorithm. A p value less than 0.05 was considered statistically significant.

Results

Distribution of accessory pathway locations in our study population



48.5% left-sided, 44% right-sided, 7.5 % AS/MS



In all, 71.5% of predictions were correct for Chiang, 72.4% for d'Avila and 71.5% for Arruda and the percentage of predictive accuracy of all algorithms did not differ between the algorithms ($p=1.000$; $p=0.875$; $p=0.885$, respectively).

Comparison of correct and incorrect predictions between the algorithms

	Arruda			p-value †
	<i>Mismatch</i>	<i>Match</i>	<i>Total</i>	
d'Avila				0.875
<i>Mismatch</i>	38 (18.4%)	19 (9.2%)	57 (27.6%)	
<i>Match</i>	21 (10.1%)	129 (62.3%)	150 (72.4%)	
<i>Total</i>	59 (28.5%)	148 (71.5%)	207 (100%)	
	Arruda			p-value †
	<i>Mismatch</i>	<i>Match</i>	<i>Total</i>	
Chiang				1.000
<i>Mismatch</i>	38 (18.4%)	21 (10.1%)	59 (28.5%)	
<i>Match</i>	21 (10.1%)	127 (61.4%)	148 (71.5%)	
<i>Total</i>	59 (28.5%)	148 (71.5%)	207 (100%)	
	d'Avila			p-value †
	<i>Mismatch</i>	<i>Match</i>	<i>Total</i>	
Chiang				0.885
<i>Mismatch</i>	34 (16.4%)	25 (12.1%)	59 (28.5%)	
<i>Match</i>	23 (11.2%)	125 (60.3%)	148 (71.5%)	
<i>Total</i>	57 (27.6%)	150 (72.4%)	207 (100%)	

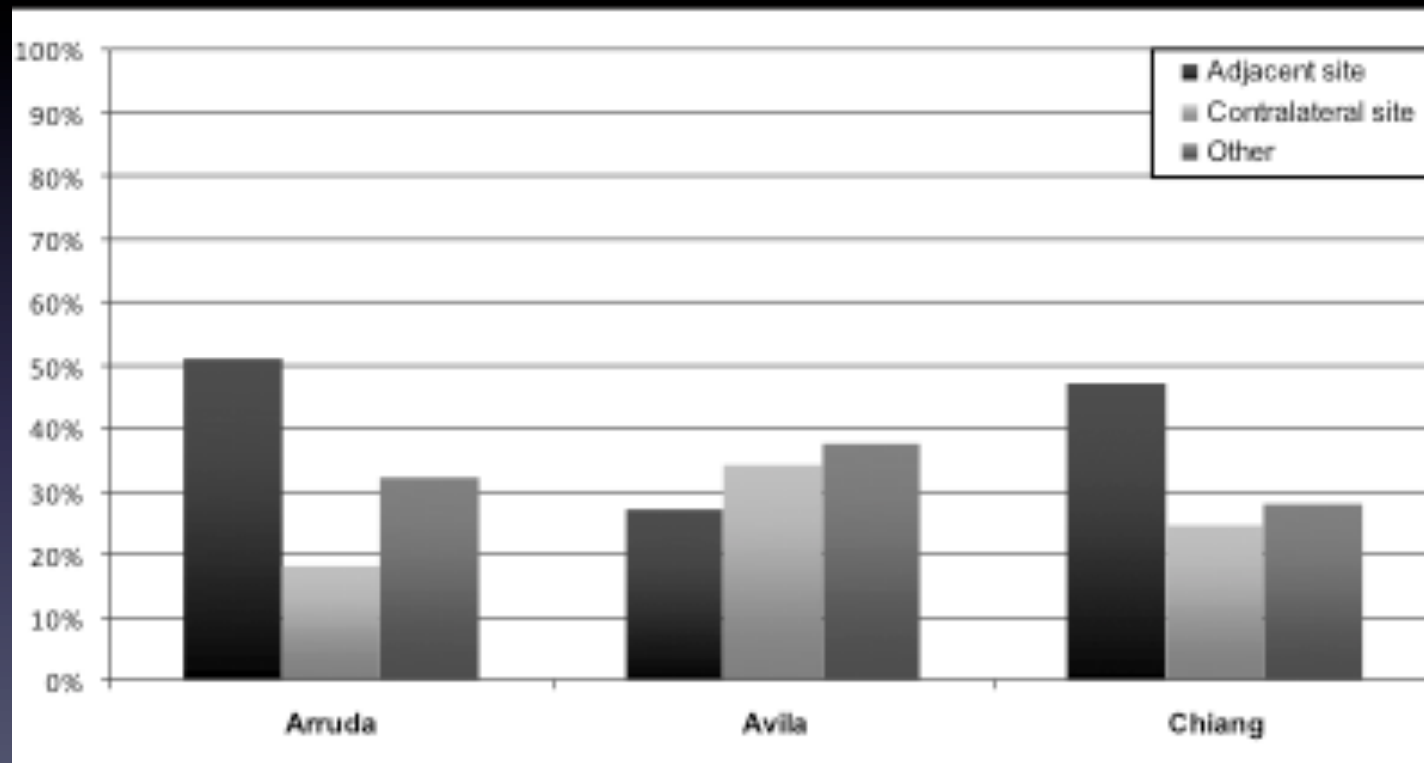
- If all predicted APs were classified according to the site of the location (i.e., right sided, left sided and anteroseptal/midseptal); the best algorithm for prediction of right-sided and left-sided APs was Arruda and the second algorithm was Chiang ($p < 0.001$). The best algorithm that particularly useful in predicting anteroseptal and midseptal APs was Arruda and the second was d'Avila ($p < 0.001$).

Comparison of the predictive accuracy of three algorithms according to the site of the accessory pathway

	Odds ratio	%95 confidence interval		Wald	p-value
		Lower	Upper		
Left-sided					
Arruda	79.693	11.987	529.832	20.519	<0.001
d'Avila	3.305	0.570	19.170	1.776	0.183
Chiang	17.979	3.536	91.427	12.123	<0.001
Right-sided					
Arruda	73.994	17.959	304.874	35.495	<0.001
d'Avila	0.969	0.232	4.047	0.002	0.966
Chiang	15.155	3.877	59.239	15.274	<0.001
Midseptal/anteroseptal					
Arruda	56.159	8.043	392.143	16.504	<0.001
d'Avila	31.278	4.241	230.665	11.406	<0.001
Chiang	0.471	0.036	6.244	0.325	0.568

- Among all inaccurate predictions; Arruda predicted 51 % adjacent site and 16.3 % contralateral site, d'Avila predicted 16% adjacent site and 34.5 % contralateral site, Chiang predicted 47.2% adjacent site and 24.5% contralateral site. In predicting adjacent sites Arruda was significantly better than d'Avila ($p=0.035$) and d'Avila showed higher percent of the contralateral site prediction than Arruda ($p=0.013$). Chiang did not show any significant difference in predicting adjacent and contralateral sites when compared to d'Avila and Arruda ($p > 0.05$).

Comparison of the percent of adjacent, contralateral and other sites predictions in the three algorithms



Discussion

- In this retrospective study, all of the three algorithms showed a similar accuracy in predicting APs. However, the accuracy of the algorithms was lower than the reported accuracy by their authors. According to the site of the AP location; Arruda showed better predictive accuracy in both left-sided, right-sided and midseptal/ anteroseptal APs than other tested algorithms. Moreover, Arruda predicted adjacent localizations better than others. When we compared the predicted contralateral site locations, d'Avila was worse than others that it referred 34% of inaccurate predictions to the contralateral site of the actual AP.

- Although the interpretation of delta wave polarity is difficult and subjective, Chiang et al. and Arruda et al. showed a detailed scheme explaining positive, negative and isoelectric delta waves that may help the interpreters more precise analyses. Previously, it was concluded that the algorithms that did not include delta wave polarity assessment in their architecture had lower accuracy in predicting APs [4].

- Therefore, in our study worse predictions with d'Avila may be explained by the former reason, and the predictive value of d'Avila algorithm may be limited by its design.

Limitations

- Owing to determination of the APs by multiple operators, some results may be subjective. However in our clinic commonly all APs were determined by biplane fluoroscopy described by Cosío et al. [8] that would intervene the variability of the interpretation.

Conclusion

- In our study, the accuracy of the tested algorithms did not reach the previously reported accuracy by their designers. The reason may be the ethnicity related differences because all of the reported algorithms tested the accuracy in different populations.

- Knowing the pathway prior to ablation allows for optimal procedure preparation, mapping pathways that are difficult to find and finally may lessen the catheter-related injury. In this regard, when the APs were classified as left-sided, right-sided and midseptal/anteroseptal, the algorithm designed by Arruda et al. may render better predictions before a planned ablation.

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