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PII: S0022-0736(17)30105-X
DOI: doi: 10.1016/j.jelectrocard.2017.04.003
Reference: YJELC 52393

To appear in: *Journal of Electrocardiology*

Please cite this article as: Jastrzebski Marek, Kukla Piotr, Czarnecka Danuta, VT score—a novel method for wide QRS complex tachycardia differentiation—explained, *Journal of Electrocardiology* (2017), doi: 10.1016/j.jelectrocard.2017.04.003

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Short Title: Ventricular tachycardia score

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Time to abandon our belief in the diagnostic utility of the wide QRS complex tachycardia algorithms

Since the time of the landmark paper by Sandler and Marriott that introduced the very first QRS morphological criteria for ventricular tachycardia (VT) diagnosis, several other criteria and algorithms have been proposed.[1-10] Almost every decade has brought a new method (**Table 1 – online only**). As a result, there are plenty of algorithms and criteria available. Why, in our opinion, was there still a need for a new ECG-based method for wide QRS complex tachycardia (WCT) differentiation?[11]

We became disillusioned with the available WCT algorithms after comparing these methods in a head-to-head fashion on our cohort of patients and discovering that none of the newer methods can beat the classic Brugada algorithm and that the average accuracy of these methods, including the Brugada algorithm, is 69 - 78% rather than 99-92% as reported by the authors (**Table 2 – online only**).[12] Other studies that assessed various ECG-based methods also have found that sensitivities, specificities and accuracies were much lower.[3,13-22] It seems that these methods result in a diagnostic mistake in every forth patient. Can any important clinical decision be based on a test that is so inaccurate? Can an ICD be implanted, long-term amiodarone therapy initiated, or empirical substrate-based VT ablation performed? Moreover, a similar diagnostic accuracy of 75% would be achieved absolutely effortlessly by considering every WCT to be a VT! It is so because only 25–30% of WCTs are supraventricular tachycardias (SVT). These facts make the very sense of usage of the elaborate algorithms very questionable.

Another sobering fact that came out along the way during our research was the lack of inclusion of 'difficult' patient sub-groups in the above-mentioned studies. It is well known that supraventricular tachycardia in a patient with overt preexcitation or in a patient on antiarrhythmic drugs might be very difficult to differentiate from ventricular ectopy. Similarly, SVT in patients with 'organic' rather than functional bundle branch blocks, especially in the setting of heart failure, might look very much like VT—with very broad or atypical bundle branch morphology (**Figures 1 and 2 – online only**)[18] On the other hand, idiopathic VTs with relatively narrow and notch-free QRS complexes often resemble aberration rather than ectopy.[23] We discovered that with few exceptions these 'difficult' patients were either excluded from these studies or there was a total lack of data concerning their inclusion (**Table 3**).[12] Moreover, some investigators decided that since preexcited SVTs resemble VT, such diagnostic mistakes should be counted as correct answers, misleadingly increasing the accuracy of the method![10, 24, 25] It seems that the classic criteria or algorithms might have been tested/developed on cohorts consisting of two well-separated subgroups: clear-cut VTs on the basis of large myocardial infraction vs. 'nice' aberrations induced during electrophysiology study in otherwise healthy patients.

Another serious limitation of the 'algorithmic approach' lies in the necessity to precisely assess all steps to reach the answer VT or SVT. What if the Vi / Vt ratio (aVR algorithm) is difficult to reliably ascertain (as is so often the case) or it is close to 1? What if the RS interval (Brugada algorithm) is close to the critical value of 100 ms? We hesitate then—is it rather 95 ms or 105 ms? In such cases we feel that our choice is arbitrary or imprecise and yet the VT or SVT diagnosis depends on this very choice. We instantly realize that the value of such a diagnosis must be weak, yet the algorithm does not allow for this. It is always 0 or 1, VT or SVT; there is no room for an 'uncertain diagnosis'.

The founding principles of the VT score method

Algorithms were constructed with the intention of not missing a VT diagnosis; in other words, sensitivity was a priority. We have decided to construct a method based on an opposite philosophy, a method that would sacrifice sensitivity but would be able to provide a firm diagnosis of VT. We believe that it is time to abandon the still often invoked, however long outdated, fear of VT under-diagnosis in the emergency department; the intravenous verapamil era is gone! In the emergency department setting, all WCTs can and should be approached as VTs (WCT = VT method) since cardioversion, amiodarone, adenosine, or lidiocaine will be relatively safe, regardless whether WCT is a VT or SVT. Adenosine administration for patients with undifferentiated WCT was proven to be safe.[26] The risk that a WCT (especially a preexcited tachycardia or a VT) after adenosine administration degenerates into an unstable rhythm seems very small and is likely completely offset when a defibrillator is ready for immediate use. Perhaps it is the VT over-diagnosis in the context of long-term management that we should be afraid nowadays, as it can result in serious clinical consequences (unnecessary defibrillator implantation,[28] inappropriate shocks, unnecessary resynchronization pacemaker upgrades, unnecessary amiodarone therapy, no referral for simple and curative SVT ablation, etc). We believe that the VT overdiagnosis is likely promoted by various popular non-specific algorithmic methods.

VT score was based on the following assumptions:

1. Wide QRS complex SVT can never be firmly diagnosed as VT can never be ruled out since some VTs are morphologically indistinguishable from SVT.
2. Only VT can be firmly diagnosed.

3. No single ECG feature for VT diagnosis is 100% specific, and, therefore, VT diagnosis should not be based on a single feature/criterion. In other words, there is no VT criterion that can never be found during SVT.
4. The more VT-specific features there are in the ECG the more likely is the VT diagnosis, at certain point reaching certainty, or near-certainty.

ECG criteria included in the VT score and VT score performance

Selection of the criteria for the VT score was initially based on the following principles: 1./ high specificity, 2./easiness of application, 3./ low margin for mistake during assessment, 4./ established position, i.e. criteria that are already well known. These criteria, initially selected on the basis of personal experience and data from literature, were tested by us in the 'construction cohort' to verify specificity and interobserver variability and to choose a set of the criteria that would result in 100% certain diagnosis of VT in the majority of VT cases.[11] The following criteria were finally included into the score:

1. Initial dominant R wave in V1

The QRS complex in V1 must start with a dominant R wave. This definition includes a monophasic R (Figure 3, A1–A6), RS when R ≥ S (Figure 3, A7–A9) and Rsr. All monophasic R wave varieties with a notch are included, except for those with the notch on the ascending limb of the R-wave when the notch's nadir is in the lower half of the R-wave, as this is a variant of supraventricular rsR′ morphology (Figure 3, A2–A5). This criterion was based on observations by Sandler and Marriott,[5] later corroborated by Wellens et al.[1] Our modification, apart from rejection of the A5 morphology (Figure 4 – online only), included

rejection of the A6-A7 morphology (qR; Figure 4 – online only) as it is not so specific for VT; such morphology is seen in RBBB and old anterior myocardial infarction.

2. Initial r > 40 ms in V1 **or** V2

It is usually fulfilled when an rS complex in V1 has a 'fat' initial 'r' (Figure 3, B1–B3). However, it also encompasses other morphologies: RS with 'r' of relatively high amplitude (Figure 3, B4), as long as R is < S, rSr, rS with notched 'r' (Figure 3, B5–B6, in V2). This criterion should be assessed only in predominantly negative QRS complexes. It is important not to forget the assessment of V2 as a rS with r > 40 ms can be present only in V2 (Figure 3, B4, B5, and B8). V1 can give no points (like in the example B7) or can give 1 point for dominant R like in the examples B4 or B5, and still the V2 can give a point for fat small 'r' wave. This criterion was introduced by Swanick and Marriott[4] and later corroborated by Kindwall et al.[7]

3. Notched S in V1

It is important to realize that although this notch is usually in the middle of the descending limb of the S wave (Figure 3, C1–C3), it can also be near the nadir (Figure 3, C4–C7) or just after the beginning of the S wave (easy to miss, see Figure 3, C8 and C9). This criterion was introduced by Kindwall et al.[7] We defined 'notch' as any change in direction, from descending to ascending, no matter how many milliseconds it lasts.

4. Initial R wave in aVR

The QRS complex in aVR has to start with a dominant R wave, including a monophasic R (with or without a notch), RS with R ≥ S and Rsr. This criterion is identical to

the Sandler & Marriott's 'Initial R in V1' criterion, but is assessed in a different lead; this criterion was introduced by Vereckei et al.[2]

5. Lead II R wave peak time (RWPT) ≥ 50 ms

The RWPT represents the interval from the beginning of the QRS to the first visible change in direction of the initial polarity, from ascending to descending or vice versa, i.e. to R-wave peak or S wave nadir or any notch on the descending limb of the S wave or the ascending limb of the R wave (**Figure 3**). It usually appears as a monophasic R or rS with a slowly increasing ascending limb of the R/r wave (Figure 3, D1 and D3, D5, D6) or an S wave with a slowly decreasing descending limb (Figure 3, D2, D4). Supraventricular lead II morphologies with short RWPT are presented in **Figure 4**. This criterion was introduced by Pava et al.[6]

6. Absence of an RS complex in leads V1–V6

This criterion is fulfilled when only QS, R, qR, Qr, rSR′, Rsr′, or other QRS configurations are present from V1 to V6, but RS/rS/Rs complex is completely absent (**Figure 5**). This criterion was introduced by Brugada et al.[9] However, it encompassed the prior Marriott's criterion of positive or negative precordial concordance and observations by Coumel et al. regarding QR / QS pattern in precordial leads during VT. [28, 29] We believe that this is the best part of the Brugada algorithm – specific, fast, and with little room for mistake in assessment, standing in contrast to the second step of this algorithm (RS > 100 ms) characterized by low specificity and to the difficult to remember and assess 4th step of this algorithm (12 possible V1-V2/V6 morphology combinations).

7. Atrioventricular dissociation

Atrioventricular dissociation during WCT is considered present when there is any indication that fast ventricular activity (QRS complexes) is not a result of atrial depolarization. Complete or partial AV dissociation can reveal itself via a plethora of ECG phenomena: clearly visible occasional p waves, sinus or retrograde, at a rate slower than QRS complexes (Figure 6 – online only, B, E and J), retrograde conduction different from 1:1, usually 2:1 (Figure 6 – online only, panels D, I and L), 3:2 (Figure 6 – online only, C) or 4:3 (Figure 6 – online only, A and K), sometimes without retrograde Wenckebach periodicity (Figure 6 – online only, panel G), fusion or capture beats (Figure 6 – online only, panel E) or a few random suspicious humps or irregularities in ST-T complex or changes in ST-T morphology (Figure 6 – online only, H and F), that, in an artifact-free ECG, are almost always *bone fide* p waves, especially when present simultaneously in more than one lead. Due to its very high specificity, this criterion was the only one assigned 2 VT score points. Some ask us why this criterion was not assigned 3 VT score points as AV dissociation is considered diagnostic for VT. Firstly, AV dissociation is not 100% specific. In our database of approx. 1000 WCTs there are only two SVTs with AV dissociation, one AV nodal reentrant,[30] and one AV nodal ectopic tachycardia. It was also reported that AV dissociation can be observed in some atrial flutters despite regular ventricular activity. [22] Moreover, mistakes in assessment occur (artifacts, changes in ST-T/QRS morphology). Furthermore, it was our observation that in a case of a true AV dissociation during VT, at least one QRS morphological feature, specific for VT, is usually also present, resulting in 3 VT score points. This is why we decided to upkeep our founding principle that no single criterion should result in a firm diagnosis of VT and assigned only 2 points for AV dissociation.

We applied these above-defined seven ECG criteria to 786 ECGs from 587 patients with WCT. Possible score was from 0 to 8 points, with 3 or more points considered indicative of a certain diagnosis of VT, 2 points of likely VT diagnosis and 0 points suggestive of SVT. Performance of the various VT scores is perhaps best reflected by the percentage of VTs and SVTs in different VT score categories—as presented in **Table 4**. In VT score 4, 5 or more there were no SVTs at all; in VT score of 3, there was one single case of a preexcited tachycardia (out of 38 preexcited WCTs that were included in the study). Therefore, when using a threshold of 3 or more there was one misdiagnosis and 294 correctly diagnosed VTs; this results in 99.7% correct diagnoses. Another interesting observation is that a presence of only one specific morphological feature (VT score = 1) puts an ECG in a true 'gray zone'—similar percentage of VTs—and SVTs have one VT-like feature. Yet another observation is that 7% of VTs do not show any VT-specific features; this corroborates our initial assumption that VT can never be excluded, or, in other words, SVT can never be firmly confirmed.

Application of the VT score is illustrated on Figure 7 (online only).

VT score limitations

A potential limitation is VT score's inability to provide a firm diagnosis in all WCT cases as only some (approx. 57% of VTs) reach the threshold of 3 VT score points. However, this inability comes from the frankness of this method and it reflects the inherent nature of electrocardiogram—ECG often does not contain enough data to allow for certain diagnosis. However, for those 'addicted' to an algorithmic 0 or 1 type of answer, for every ECG case, VT score can be used as an algorithm; for this, the threshold has to be lowered from 3 points to 1 VT score point. Then, VT score acts precisely as an algorithm: if any of the criteria is present we diagnose VT; if none is present we diagnose SVT. While not 100% accurate, such use of VT score still results in superior overall accuracy to the other methods. Not to mention

that we omit the use of cumbersome steps like calculation of Vi/Vt in the aVR algorithm or search for 12 possible criteria combinations in the fourth step of the Brugada algorithm.

Conclusions

A new method, based on a different philosophy from the previous methods for WCT diagnosis, was constructed and validated on largest to-date cohort of WCTs. Its philosophy and criteria were explained while potential merits are summarized in **Table 5 (online only)**.

References

[1] Wellens HJ, Bar FW, Lie KI. The value of the electrocardiogram in the differential diagnosis of a tachycardia with a widened QRS complex. Am J Med 1978;64:27-33.

[2] Vereckei A, Duray G, Szenasi G, Altemose GT, Miller JM. Application of a new algorithm in the differential diagnosis of wide QRS complex tachycardia. Eur Heart J 2007;28:589-600.

[3] Vereckei A, Duray G, Szenasi G, Altemose GT, Miller JM. New algorithm using only lead aVR for differential diagnosis of wide QRS complex tachycardia. Heart Rhythm 2008;5:89-98.

[4] Swanick EJ, LaCamera F, Jr., Marriott HJ. Morphologic features of right ventricular ectopic beats. Am J Cardiol 1972;30:888-91.

[5] Sandler IA, Marriott HJ The differential morphology of anomalous ventricular complexes of RBBB-type in lead V1: ventricular ectopy versus aberration. Circulation 1965;31:551-6.

[6] Pava LF, Perafan P, Badiel M et al. R-wave peak time at DII: a new criterion for differentiating between wide complex QRS tachycardias. Heart Rhythm 2010;7:922-6.

[7] Kindwall KE, Brown J, Josephson ME. Electrocardiographic criteria for ventricular tachycardia in wide complex left bundle branch block morphology tachycardias. Am J Cardiol 1988;61:1279-83.

[8] Griffith MJ, Garratt CJ, Mounsey P, Camm AJ. Ventricular tachycardia as default diagnosis in broad complex tachycardia. Lancet 1994 February 12;343[8894]:386-8.

[9] Brugada P, Brugada J, Mont L, Smeets J, Andries EW. A new approach to the differential diagnosis of a regular tachycardia with a wide QRS complex. Circulation 1991;83:1649-59.

[10] Lau EW, Pathamanathan RK, Ng GA, Cooper J, Skehan JD, Griffith MJ. The Bayesian approach improves the electrocardiographic diagnosis of broad complex tachycardia. Pacing Clin Electrophysiol 2000;23:1519-26.

[11] Jastrzebski M, Sasaki K, Kukla P, Fijorek K, Stec S, Czarnecka D. The ventricular tachycardia score: a novel approach to electrocardiographic diagnosis of ventricular tachycardia. Europace 2016;18:578-84.

[12] Jastrzebski M, Kukla P, Czarnecka D, Kawecka-Jaszcz K. Comparison of five electrocardiographic methods for differentiation of wide QRS-complex tachycardias. Europace 2012;14:1165-71

[13] Alberca T, Almendral J, Sanz P, Almazan A, Cantalapiedra JL, Delcan JL. Evaluation of the specificity of morphological electrocardiographic criteria for the differential diagnosis of wide QRS complex tachycardia in patients with intraventricular conduction defects. Circulation 1997;96:3527-33.

[14] Baxi RP, Hart KW, Vereckei A et al. Vereckei criteria used as a diagnostic tool by emergency medicine residents to distinguish between ventricular tachycardia and supra-ventricular tachycardia with aberrancy. J Cardiol 2012;59:307-12.

[15] Ceresnak SR, Liberman L, Avasarala K, Tanel R, Motonaga KS, Dubin AM. Are wide complex tachycardia algorithms applicable in children and patients with congenital heart disease? J Electrocardiol 2010;43:694-700.

[16] Griffith MJ, de Belder MA, Linker NJ, Ward DE, Camm AJ. Multivariate analysis to simplify the differential diagnosis of broad complex tachycardia. Br Heart J 1991;66:166-74.

[17] Isenhour JL, Craig S, Gibbs M, Littmann L, Rose G, Risch R. Wide-complex tachycardia: continued evaluation of diagnostic criteria. Acad Emerg Med 2000;7:769-73.

[18] Jastrzebski M, Kukla P, Czarnecka D, Kawecka-Jaszcz K. Specificity of the wide QRS complex tachycardia algorithms in recipients of cardiac resynchronization therapy. J Electrocardiol 2012;45:319-26.

[19] Lau EW, Ng GA. Comparison of two diagnostic algorithms for regular broad complex tachycardia by decision theory analysis. Pacing Clin Electrophysiol 2001;24:1118-25.

[20] Lau EW, Ng GA. Comparison of the performance of three diagnostic algorithms for regular broad complex tachycardia in practical application. Pacing Clin Electrophysiol 2002;25:822-7.

[21] Sasaki K. Abstract 2650: A New, Simple Algorithm for Diagnosing Wide QRS Complex Tachycardia: Comparison With Brugada, Vereckei and aVR Algorithms . Circulation 2009;120: S671.

[22] V N Nathwani, K W Wong, J Jones et al. Comparative accuracy of standard ECG algorithms for the diagnosis of broad complex tachycardia in cases of atrial flutter with 1 to 1 conduction. Heart 99 [Suppl S2], A44; doi:10.1136/heartjnl-2013-304019.67. 2013.

[23] Wijnmaalen AP, Stevenson WG, Schalij MJ et al. ECG Identification of Scar-Related Ventricular Tachycardia With a Left Bundle-Branch Block Configuration. Circ Arrhythm Electrophysiol 2011;4:486-93.

[24] Jastrzebski M, Kukla P. Limitations in the aVR algorithm should not lead to a redefinition of ventricular tachycardia. Europace 2012; 14:1674-5.

[25] Vereckei A, Miller JM. Classification of pre-excited tachycardias by electrocardiographic methods for differentiation of wide QRS-complex tachycardias. Europace 2012;14:1674-5.

[26] Marill KA, Wolfram S, DeSouza IS et al. Adenosine for wide-complex tachycardia: efficacy and safety. Crit Care Med 2009; 37:2512–8.

[27] Becker R, Melkumov M, Senges-Becker JC et al. Are electrophysiological studies needed prior to defibrillator implantation? Pacing Clin Electrophysiol 2003;26:1715-21.

[28] Coumel P, Leclercq JF, Attuel P, Maisonblanche P. The QRS morphology in post-myocardial infarction ventricular tachycardia. A study of 100 tracings compared with 70 cases of idiopathic ventricular tachycardia. Eur Heart J 1984;5:792-805.

[29] Marriott HJ. Differential diagnosis of supraventricular and ventricular tachycardia. Geriatrics 1970;25:91-101.

[30] Jastrzebski M, Kukla P. Supraventricular tachycardia with broad QRS complexes and atrioventricular dissociation - is that possible?. Kardiol Pol 2013;71:527-30.

Figure 1. ECG of a 69-year old man with dilated cardiomyopathy, advanced heart failure and LV ejection fraction of 19%. AAI pacing 100 bpm, LBBB with first degree AV block. The aVR algorithm points to VT diagnosis (presence of a notch on the downstroke of a negative onset and predominantly negative QRS in lead aVR, third step of the algorithm). The Griffith algorithm points to VT diagnosis (S wave nadir > 70 ms in V1-V2). The Brugada algorithm points to VT diagnosis (R to S interval > 100 ms in precordial leads V3-V4, second step of the algorithm). The Bayesian algorithm points to VT diagnosis with posterior odds of 5910. Only the Pava criterion (RWPT = 30 ms) correctly identifies this QRS morphology as supraventricular. Reproduced with permission from Jastrzebski et al. *J Electrocardiol* 2012.

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Figure 2. ECG of a 63-year old man with coronary heart disease, advanced heart failure and LV ejection fraction of 35%. Sinus rhythm of 100 bpm. The Pava criterion (RWPT = 50 ms) points to VT diagnosis. The Brugada algorithm points to VT diagnosis (R to S interval > 100 ms in precordial leads V3-V4, second step of the algorithm). The Griffith algorithm point to VT diagnosis (S wave nadir > 70 ms in V2). The Bayesian algorithm points to VT diagnosis with posterior odds of 5910. Only the aVR algorithm correctly identifies this QRS morphology as supraventricular (in the fourth step). Reproduced with permission from Jastrzebski et al. *J Electrocardiol* 2012. [18]

Figure 3. VT score criteria; representative QRS morphologies. For panel descriptions see the text. Reproduced with permission from Jastrzebski et al. *Europace 2016*. [11]

Figure 4. Examples of QRS morphologies in leads V1 and II that do not fulfill the criteria of VT score morphologies. Panel A1: classic rsR' pattern of right bundle branch block. Panels A2-A5: Notch on the ascending limb of the R wave with the notch's nadir in the lower part of the R wave. Panels A6-A7: qR pattern. Panels B1-B4: Short RWPT (R-wave peak time): from the beginning of the QRS to the r or R wave peak there is < 50 ms. Panels B5 and B6: Short interval from the beginning of the QRS to the S wave notch. Reproduced with permission from Jastrzebski et al. *Europace 2016*. [11]

Figure 5. Examples of various patterns compatible with lack of an RS complex in leads V1-V6. Including negative concordance (panel A), positive concordance (panel B) and various combinations of qR, QR, R and rSr' complexes (remaining panels).

Figure 6. Examples of various patterns indicating the presence of complete or partial AV dissociation. For panel descriptions see the text.

Figure 7. Wide QRS complex tachycardia. Three 'fast and easy' VT score points can be given for: 'fat' r in V1, dominant R in aVR and long time to nadir in lead II (RWPT). Therefore, certain VT should be diagnosed. This was a correct diagnosis. One may remark that Brugada algorithm, Pava method and aVR algorithm would also diagnose VT in this case. Yes, these methods would also point to a diagnosis of VT, however, with 20-30% potential for incorrect answer. Can we trust such an answer? In contrast, VT score potential for mistake here is 0.3%. Paper speed 25 mm/s

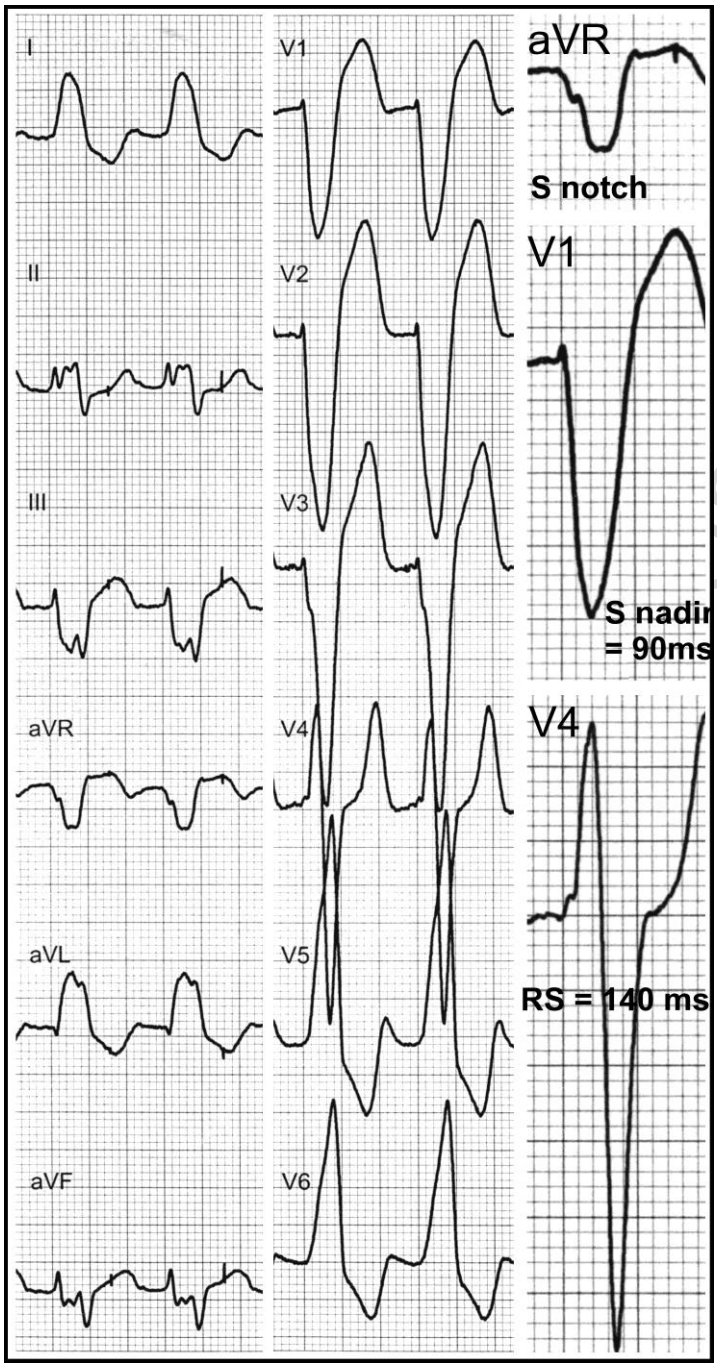

Figure 1

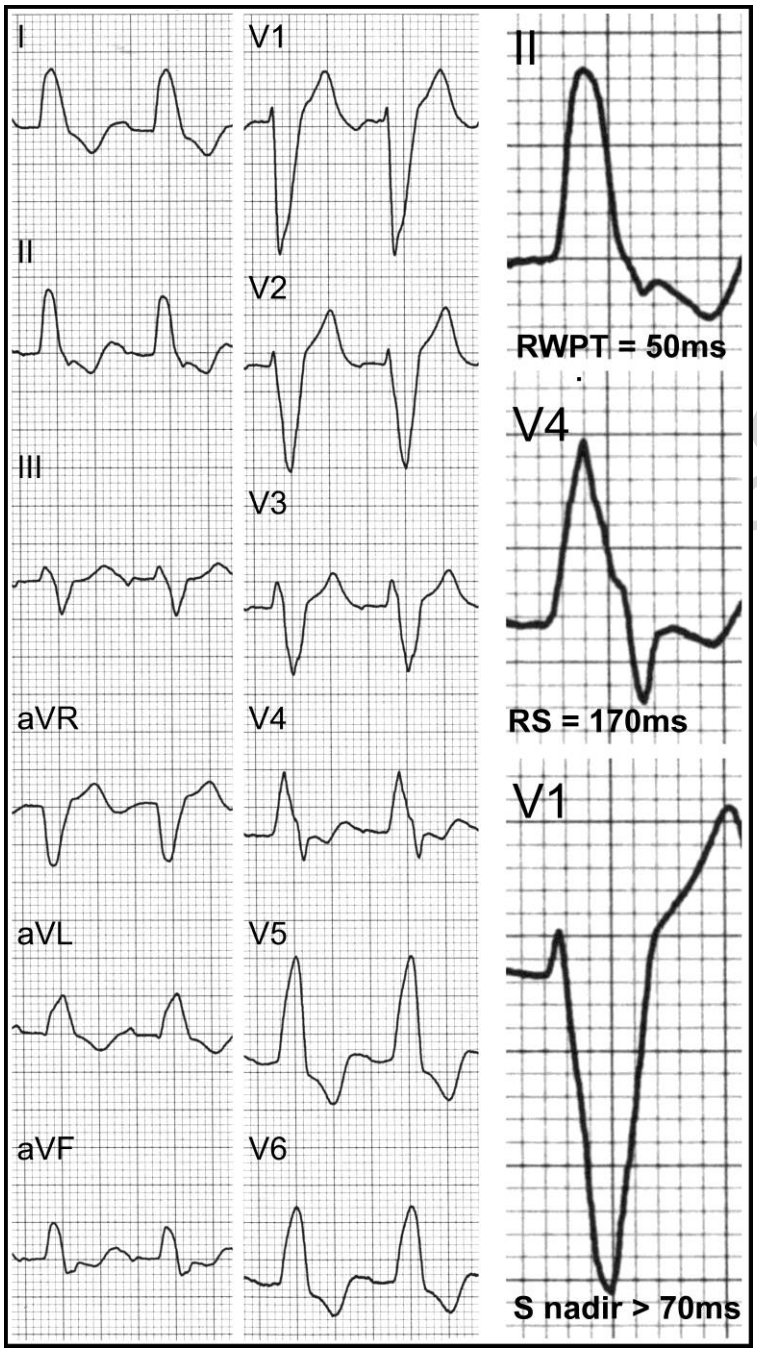

Figure 2

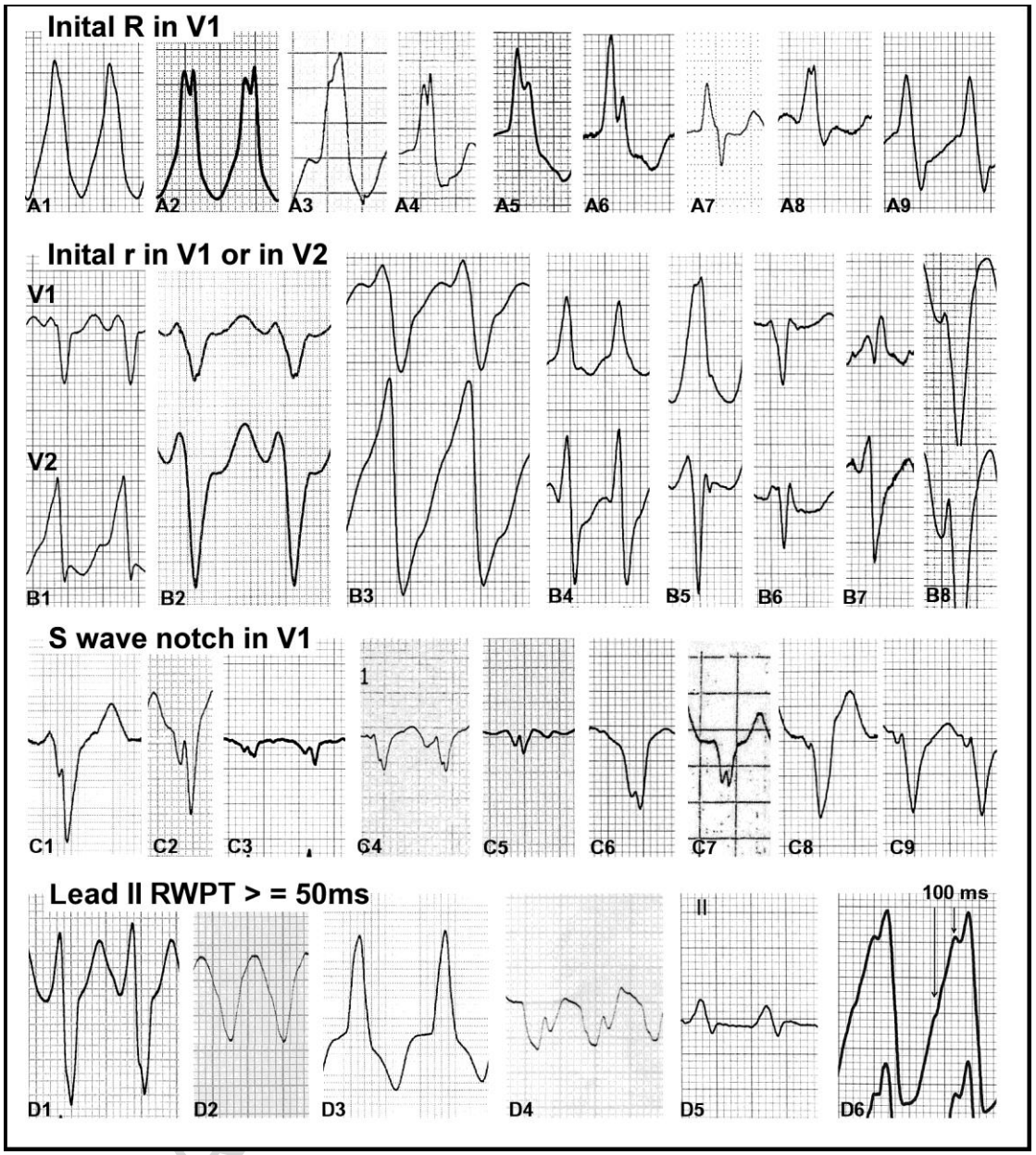

Figure 3

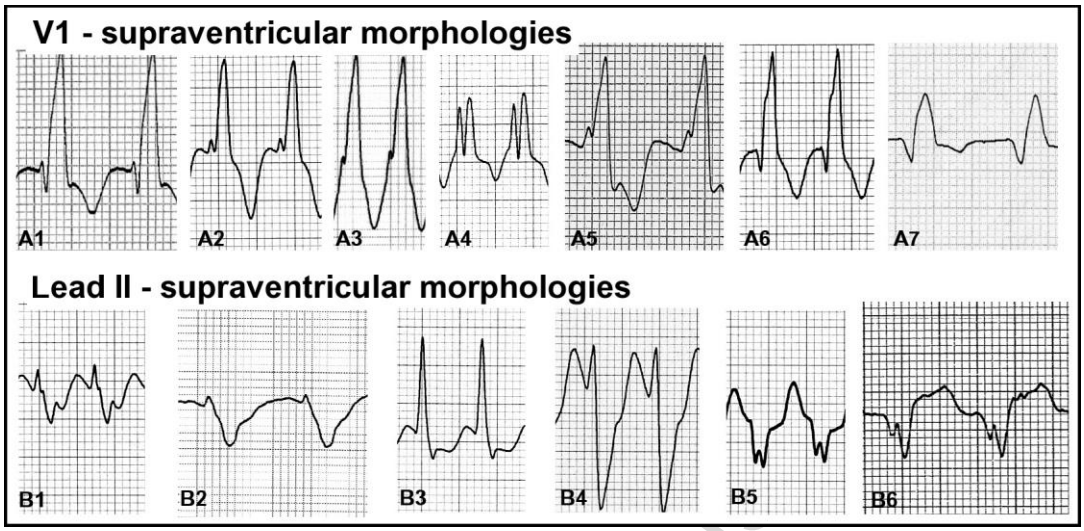

Figure 4

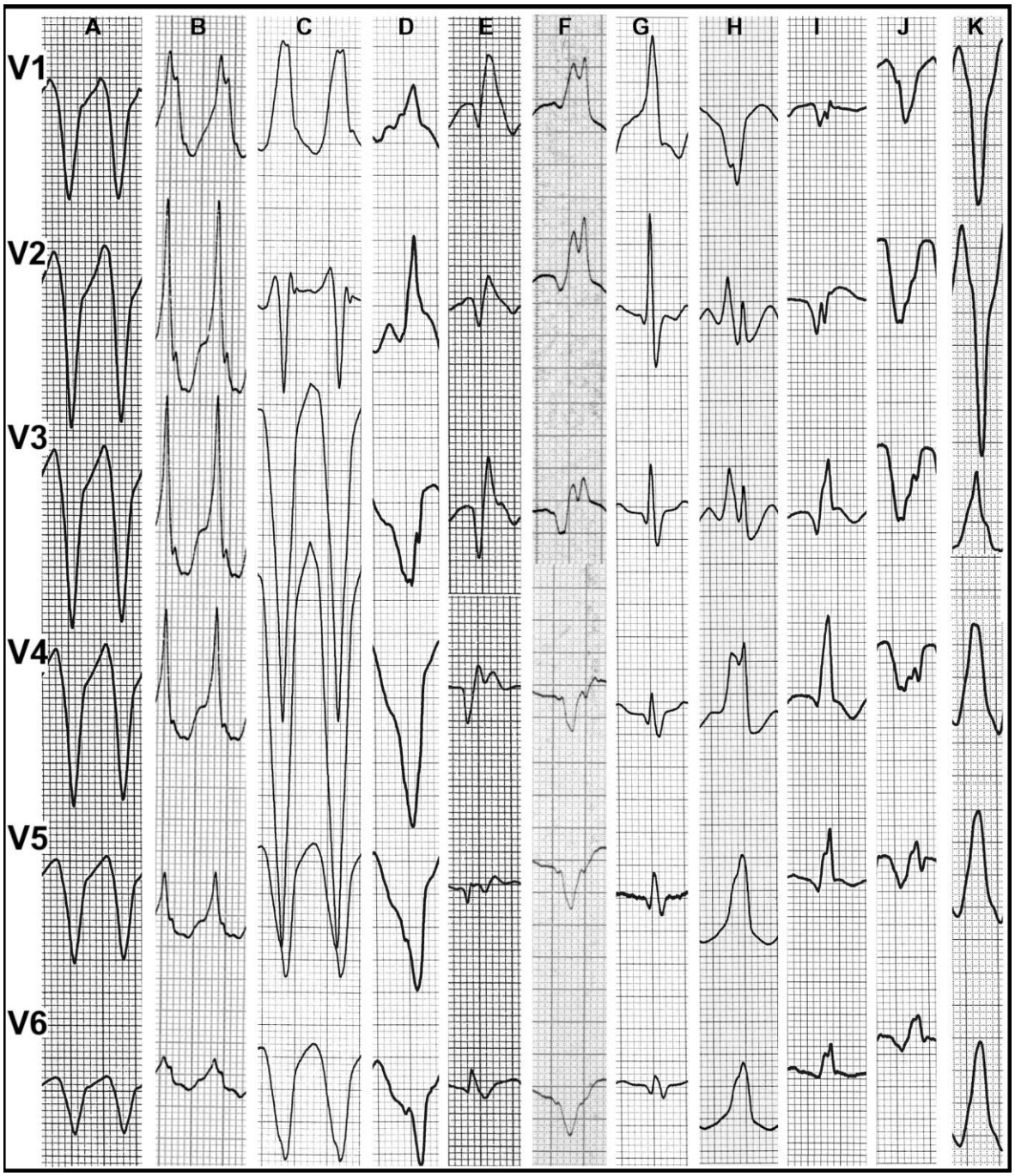

Figure 5

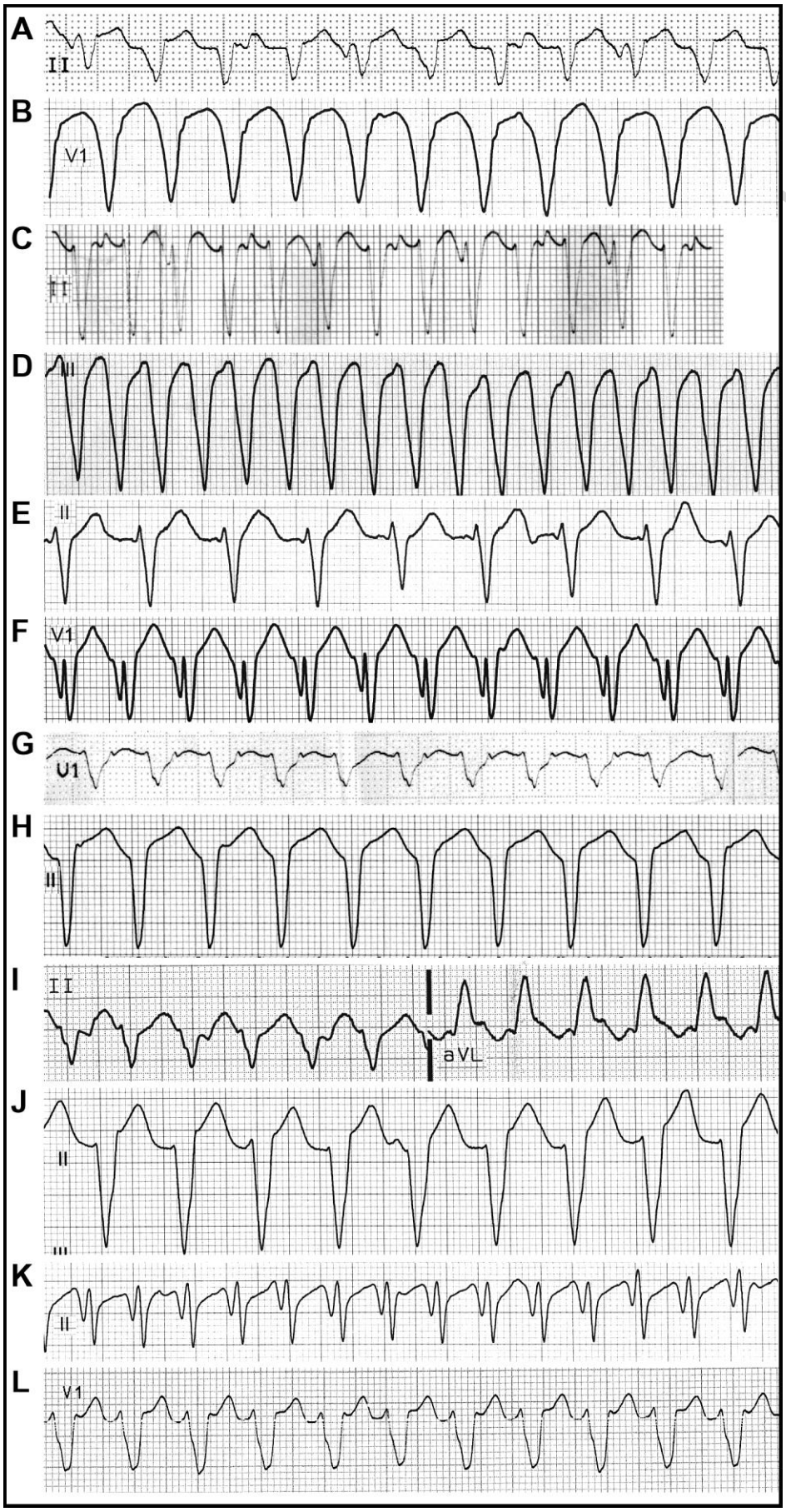

Figure 6

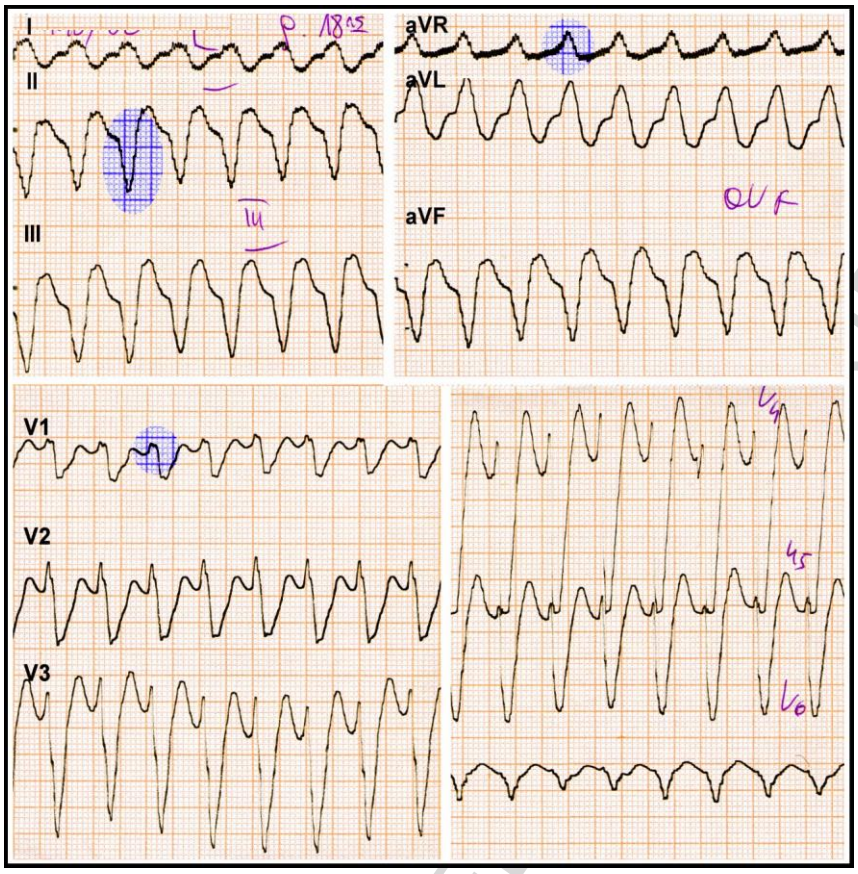

Figure 7

Table 1. 50 years of ECG criteria and algorithms for wide QRS tachycardia diagnosis

Sandler & Marriott	*Circulation 1965*	*n = 200*	Several new V1 RBBB criteria
Swanick & Marriott	*Am J Cardiol 1972*	*n = 184*	1 new V1 LBBB criterion
Wellens	*Am J Med. 1978*	*n = 140*	3 new criteria
Kindwall	*Am J Cardiol 1988*	*n = 118*	2 new V1 LBBB criteria
Brugada	*Circulation 1991*	*n = 544*	15 criteria (2 new) in a 4-step algorithm
Griffith	*Lancet 1994*	*n = 102*	5 criteria in 2-step algorithm
Lau (Bayesian)	*PACE 2000*	*n = 244*	21 criteria - likelihood ratio calculation
Vereckei (aVR 1)	*Eur Heart Jour 2007*	*n = 453*	10 criteria (2 new) in a 4-step algorithm
Vereckei (aVR 2)	*Heart Rhythm 2008*	*n = 483*	4 criteria (4 new) in a 4-step algorithm,
Pava (lead II RWPT)	*Heart Rhythm 2010*	*n =163*	1 criterion (new)
Jastrzebski (VT score)	*Europace 2015*	*n = 786*	7 criteria in a score system

Table 2. Sensitivity, specificity, positive and negative likelihood ratios for VT diagnosis and overall diagnostic accuracy (percentage of correct diagnoses) for 5 methods of WCT differentiation. With permission from Jastrzebski et al, Europace 2012. [18]

	Brugada	Griffith	Bayesian	Lead aVR	Lead II RWPT	p
Accuracy [%]	77.5 (71.8 - 82.5)	73.1 (67.2 - 78.5)	74.7 (68.9 - 79.9)	71.9 (66.0 - 77.4)	68.8 (62.7 - 7.44)	0.04*
Specificity [%]	59.2 (48.8 - 69.0)	39.8 (30.0 - 50.2)	52.0 (41.7 - 62.2)	48.0 (37.8 - 58.3)	82.7 (73.7 - 89.6)	<0.001**,#
Sensitivity [%]	89.0 (83.0 - 93.5)	94.2 (89.3 - 97.3)	89.0 (83.0 - 93.5)	87.1 (80.8 - 91.9)	0.60 (0.52 ; 0.68)	<0.001**, ##
LR(+)	2.18 (1.71 - 2.78)	1.56 (1.33 - 1.85)	1.86 (1.50 - 2.30)	1.67 (1.37 - 2.04)	3.46 (2.20 - 5.43)	-
LR(-)	0.18 (0.11 - 0.30)	0.15 (0.07 - 0.29)	0.21 (0.13 - 0.34)	0.27 (0.17 - 0.42)	0.48 (0.39 - 0.60)	-

Numbers in parentheses are the 95% confidence intervals.

* Brugada vs. lead II RWPT

** Lead II RWPT vs. any other algorithm

\# p = 0.01 for Griffith vs. Brugada or vs. Bayesian

\## p = 0.05 for Griffith vs. aVR

Table 3. WCT types included in the studies that introduced differentiation criteria or algorithms. Modified with permission from Jastrzebski et al, Europace 2012. [18]

	Preexisting bundle branch block	Preexcited tachycardias	Idiopathic VTs	Antiarrhythmic drug use
Wellens et al.[1]	**0**	**0**	**?**	**0**
Kindwall et al.[8]	15 (12.7%)	**0**	5 (4.2%)	12 (10.1%); **0** with SVT
Brugada et al.[10]	**?**	**?**	**?**	0 ##
Griffith et al.[9]	**?**	**?**	≥5 (≥4.9%) ###	**?**
Lau et al.[7]	**?**	**0** (8.2%)*	10 (4.1%)**	**?**
Vereckei et al.[3]	144 (29.8%)	20 (4.1%)*	38 (7.9%)	158 (32.7%)
Pava et al.[6]	**?**	**?** (one case?)	6 (2.7%) ***	**?**
Jastrzebski et al.[11]	169 (28.8%)	38 (6.5%)	58 (9.9%)	74 (12.6%)

? means that **<u>no data</u>** can be found in the original publication

no firm data, however, excluded from the first part of the study

no firm data, albeit 5 RVOT VTs mentioned in the results

* somewhat extraordinarily preexcited tachycardias were grouped with VTs (!)

** data available only for some idiopathic VT types (for fascicular VTs)

*** data available only for fascicular VTs and uncertain—mentioned imprecisely in the discussion

Table 4. Distribution of VT scores in the entire studied population (n=786). Reproduced with permission from Jastrzebski et al. *Europace 2016*. [11]

Diagnosis	VT score					
	0	**1**	**2**	**3**	**4**	**≥5**
SVT (n)	174	70	29	1	0	0
VT (n)	32	84	102	127	97	70
Percentage of VT in this VT score category	15.5%	54.5%	77.9%	99.2%	100%	100%

$p < 0.001$ (for trend)

VT, ventricular tachycardia; SVT, supraventricular tachycardia.

Table 5. VT score highlights

Provides a firm diagnosis of VT when such is possible

Grades the 'strength' of the VT diagnosis

Identifies 'grey zone' ECGs

Has superior overall accuracy and unparalleled specificity

Takes best criteria from the previous methods, giving due credit to their inventors

All 7 criteria all already well known—easy to remember and use

Is elastic—one can skip criteria difficult to ascertain, while still maintaining high specificity