ECG in Tachyarrhythmias
Systematic Approach

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Looking for the following:

1. QRS complex width.
2. QRS complex regularity.
3. Presence of P wave.
4. P wave morphology.
5. P wave relationship to QRS.
6. P wave rate and QRS rate.

Classification of WCT

Wide QRS complex tachycardia

Irregular

1. AF with BBB.
2. Pre-excited AF.
3. Atrial flutter with variable AV ratio.
4. Torsades de pointes.

Regular

1. VT
2. V Flutter
3. Pre-excited tachycardia.
4. SVT with aberration:
   - Sinus Tachycardia
   - Atrial Tachycardia
   - AVNRT
   - AVRT
   - Atrial flutter with fixed AV ratio

- **Is It important to differentiate VT from SVT with aberration ?!**

  - Definitely, If you wrongly managed a patient with VT with underlying Heart disease as having SVT with aberration and gave him isoptin → severe haemodynamic deterioration necessitating immediate cardioversion may occur.

  - Furthermore, hypotension with resulting ischaemia may render the arrhythmia impossible to cardiovert.

  - Morover, long term management is different.

Systematic ECG evaluation of WCT

1- QRS width:

- 140 msec in RBBB &
- 160 msec in LBBB favors a diagnosis of VT.

  NB: Exceptions are possible as pre-excited tachycardias which may be that wide and as ventricular tachycardia in digitalis toxicity that may have a QRS duration <0.14 sec as it originates in one of the bundle branches.
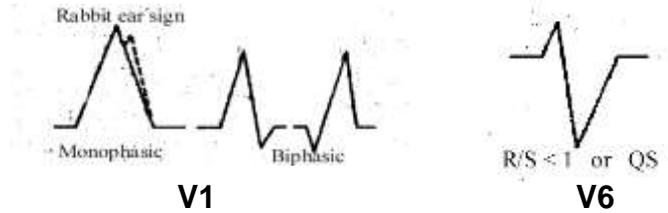
2- QRS Axis:

- An abnormal axis is a strong indicator of VT.
- This is specially true of an axis in the northwest quadrant (-90 degrees to –180).

3- QRS configuration in VT :

a- V1- positive i.e RBBB pattern :

V1   **V6**

NB: When there are two positive peaks in lead V1, ventricular tachycardia is very likely if the left peak is taller. This is known as the rabbit ear sign, and is shown in the previous figure with dotted line. A taller right rabbit ear is of no Help in distinguishing V tach. from aberration.

b- V1- negative i.e LBBB pattern :

V1 – V2   **V6**
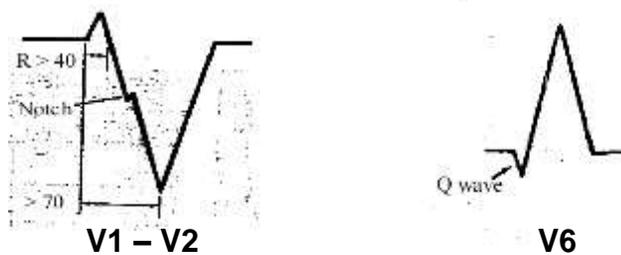
Four signs are highly predictive of VT:

1. A broad R of 0.04 sec or more in lead V1 or V2.
2. A slurred or notched S downstroke in lead V1 or V2.
3. A distance of 0.07 sec or more from the onset of the QRS to the nadir of the QS or S in lead V1 or V2.
4. Any Q in lead V6.

4- AV dissociation:

- Diagnostic of VT if P waves are less than QRS numbers.

- Detection of regular independant P waves is a very strong diagnostic sign. However, P wave identification may be difficult or impossible, therefore the evaluation of the QRS morphology and a physical examination for AV dissociation are faster and more reliable

5- Concordant Precordial Pattern:

- Totally -ve pattern → almostly a VT.
- Totally +ve pattern → Lt Vent.VT or
  → Pre-excited SVT using LL AP.
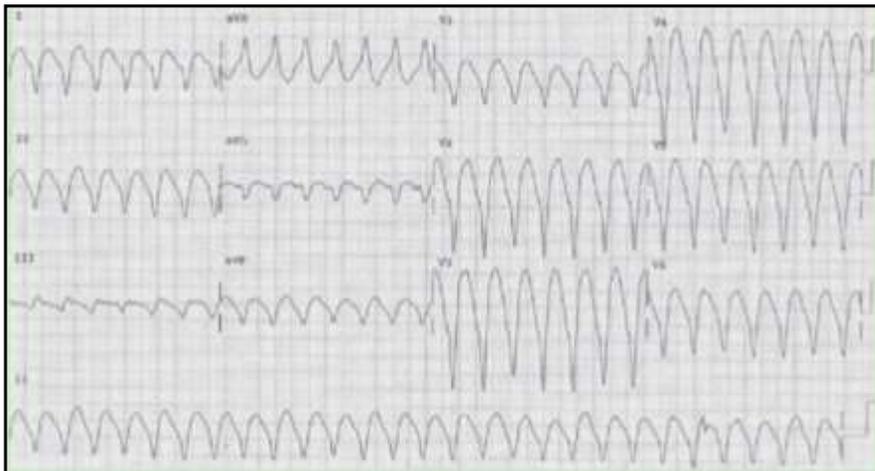
6- Narrow beats during wide QRS Tachycardia :

- A conducted sinus beat leading to capture or fusion beat. Both produce a complex narrwer than the VT.

- An echo beat: it is a form of capture or fusion beat due to downward conduction to the V of an impulse that was originally retrogradely conducted.
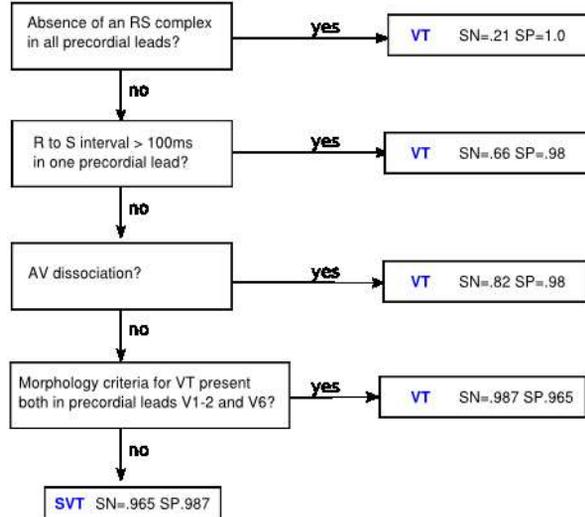
- Fusion between two V ectopic foci.

ECG algorithms to differentiate WCT

I- Brugada algorithm

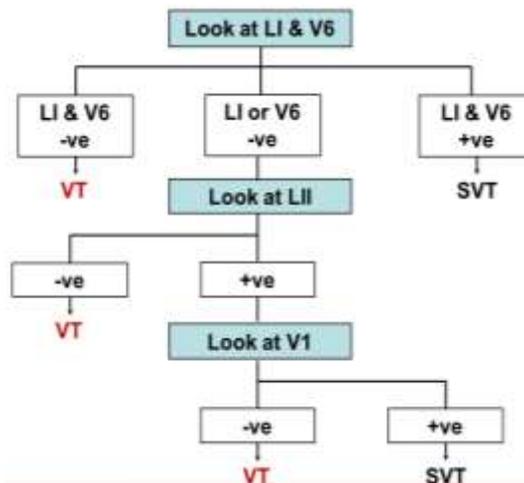Most commonly used.

- Sensitivity = 89%

- Specificity = 59.2%

Absence of an RS complex in all precordial leads? — **yes** → **VT** SN=.21 SP=1.0

no

R to S interval > 100ms in one precordial lead? — **yes** → **VT** SN=.66 SP=.98

no

AV dissociation? — **yes** → **VT** SN=.82 SP=.98

no

Morphology criteria for VT present both in precordial leads V1-2 and V6? — **yes** → **VT** SN=.987 SP.965

no

SVT SN=.965 SP.987

Brugada P et al. *Circulation* 1991; 83(5): 1649-1659

II- Four Lead Criteria (I, II, V1 & V6)

- If two or more of these leads are –ve QRS complex (QS, rS) including lead I & V6 → VT is diagnostic (> 85% accuracy).

- Otherwise consider SVT with aberration or antidromic tachycardia.

- Sensitivity = 86%

- Specificity = 100%

Look at LI & V6

LI & V6 -ve → VT

LI or V6 -ve → Look at LII

LI & V6 +ve → SVT

-ve → VT

+ve → Look at V1

-ve → VT

+ve → SVT

Farouk K et al. *Egyptian Heart Journal* 1999

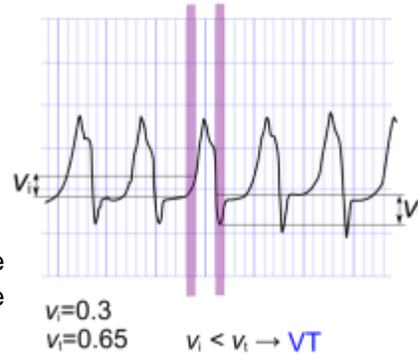## III- Vereckei algorithm

Step 1: Presence of AV dissociation.

Step 2: Presence of an initial R wave in lead aVR.

Step 3: Whether the morphology of the WCT correspond to bundle branch or fascicular block.

$v_i=0.3$
$v_t=0.65$ $v_i < v_t \rightarrow$ VT

Step 4: an index of slow conduction at the beginning and at the end of the QRS complex by estimation of initial (v_i) and terminal (v_t) ventricular activation velocity ratio (v_i/v_t), obtained by measuring the voltage in millivolts on the ECG tracing the impulse travelled vertically during the initial 40 ms (v_i) and the terminal 40 ms (v_t) of the same bi- or multiphasic QRS complex.
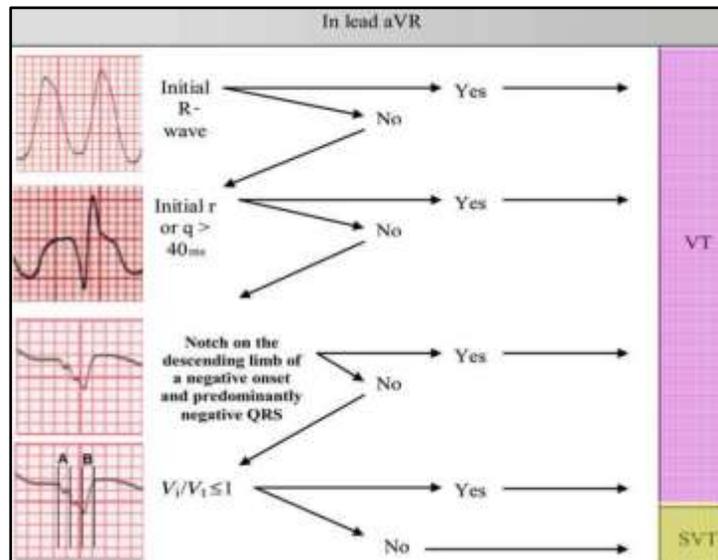
Vereckei A et al. *Eur Heart J* 2007; 28(5): 589-600
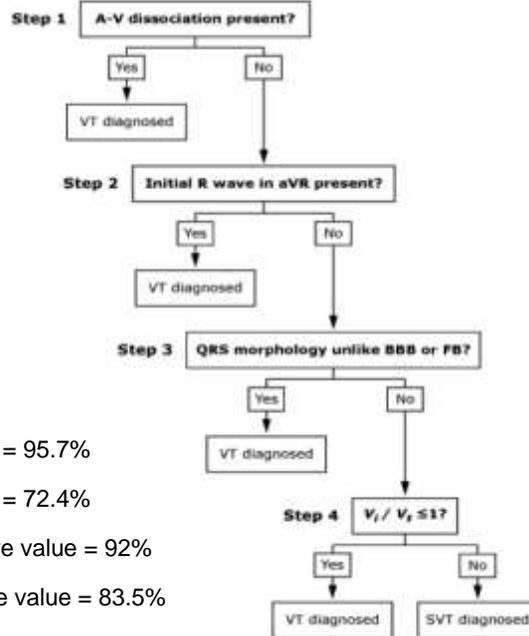
- Sensitivity = 95.7%

- Specificity = 72.4%

- + Predictive value = 92%
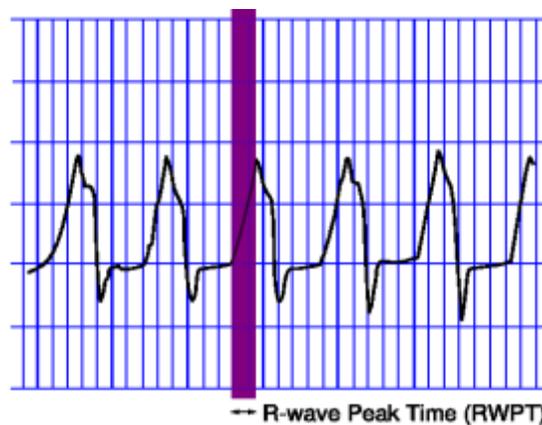
- - Predictive value = 83.5%

IV- Vereckei aVR algorithm

V- Ultrasimple Brugada criterion
RW to peak Time (RWPT) in lead II

- RWPT duration at lead II measured from the isoelectric line to the point of first change in polarity (either nadir Q or peak R) in lead II.
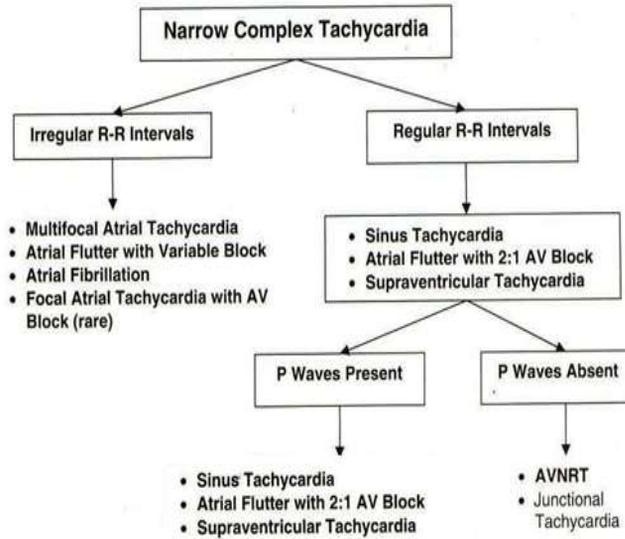
RWPT ≥ 50ms → VT

- Sensitivity = 93.2%
- Specificity = 99.3%
- + Predictive value = 98.2%
- - Predictive value = 93.3%

R-wave Peak Time (RWPT)
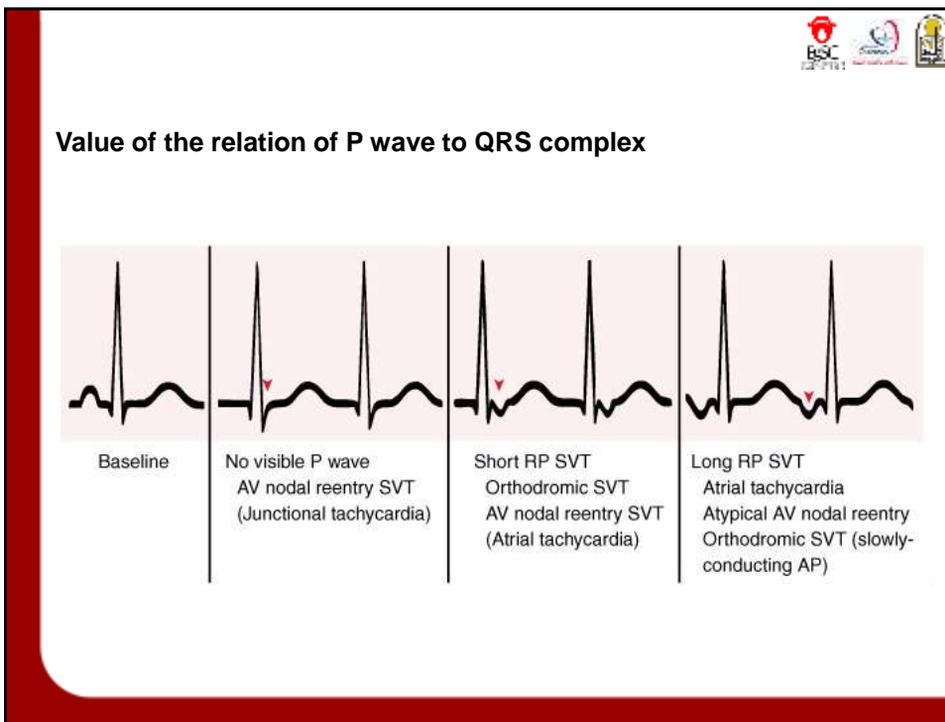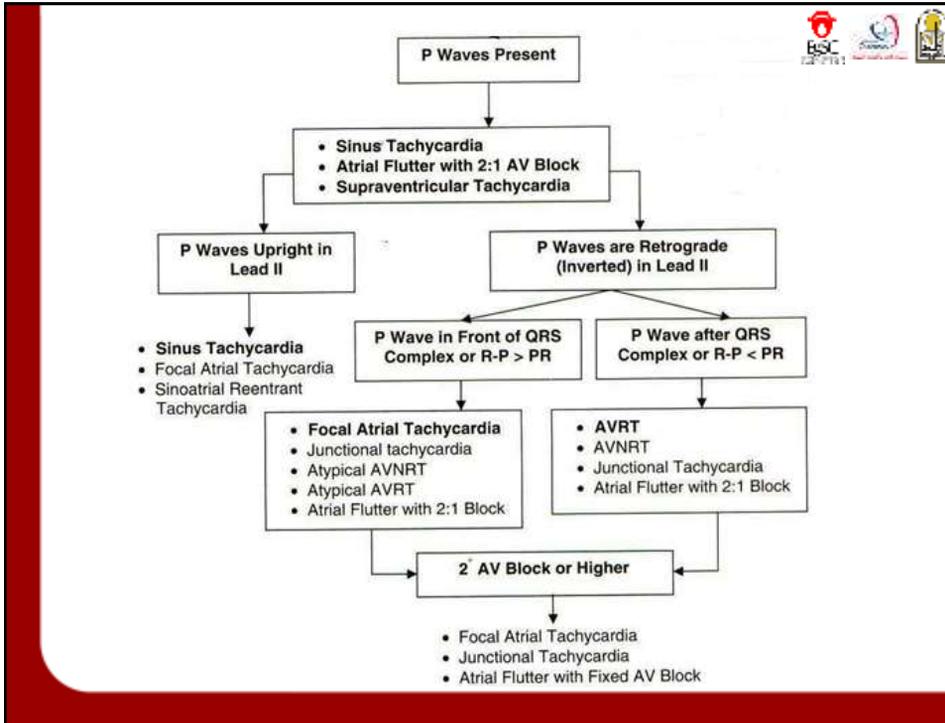
Simple algorithm to differentiate NCT

Narrow Complex Tachycardia

Irregular R-R Intervals

Regular R-R Intervals

- Multifocal Atrial Tachycardia
- Atrial Flutter with Variable Block
- Atrial Fibrillation
- Focal Atrial Tachycardia with AV Block (rare)

- Sinus Tachycardia
- Atrial Flutter with 2:1 AV Block
- Supraventricular Tachycardia

P Waves Present

P Waves Absent

- Sinus Tachycardia
- Atrial Flutter with 2:1 AV Block
- Supraventricular Tachycardia

- AVNRT
- Junctional Tachycardia
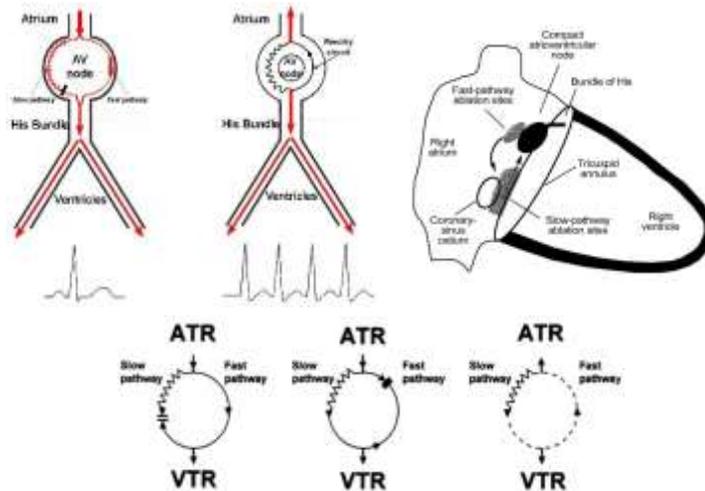
Value of the presence of P wave

Lead II

Possible Diagnoses

Sinus Tachycardia
Sinoatrial Reentrant Tachycardia
Focal Atrial Tachycardia

Focal Atrial Tachycardia
Junctional Tachycardia
Atypical AVNRT
Atypical AVRT

AVNRT
Junctional Tachycardia

Junctional Tachycardia
AVNRT

AVRT
AVNRT
Junctional Tachycardia

AVNRT
Junctional Tachycardia

AVRT
Atrial Flutter with 2:1 AV Block
AVNRT
Focal Atrial Tachycardia
Junctional Tachycardia

Multifocal Atrial Tachycardia

Nonparoxysmal Junctional Tachycardia with Complete AV Dissociation

Slide 1

```
                    ┌──────────────────┐
                    │  P Waves Present │
                    └──────────────────┘
                             │
              ┌──────────────────────────────────┐
              │ • Sinus Tachycardia              │
              │ • Atrial Flutter with 2:1 AV Block│
              │ • Supraventricular Tachycardia   │
              └──────────────────────────────────┘
```

P Waves Present

- Sinus Tachycardia
- Atrial Flutter with 2:1 AV Block
- Supraventricular Tachycardia

P Waves Upright in Lead II

P Waves are Retrograde (Inverted) in Lead II

- Sinus Tachycardia
- Focal Atrial Tachycardia
- Sinoatrial Reentrant Tachycardia

P Wave in Front of QRS Complex or R-P > PR

P Wave after QRS Complex or R-P < PR

- **Focal Atrial Tachycardia**
- Junctional tachycardia
- Atypical AVNRT
- Atypical AVRT
- Atrial Flutter with 2:1 Block

- AVRT
- AVNRT
- Junctional Tachycardia
- Atrial Flutter with 2:1 Block

2° AV Block or Higher

- Focal Atrial Tachycardia
- Junctional Tachycardia
- Atrial Flutter with Fixed AV Block

Slide 2

Value of the relation of P wave to QRS complex

| Baseline | No visible P wave AV nodal reentry SVT (Junctional tachycardia) | Short RP SVT Orthodromic SVT AV nodal reentry SVT (Atrial tachycardia) | Long RP SVT Atrial tachycardia Atypical AV nodal reentry Orthodromic SVT (slowly-conducting AP) |

ECG in AVNRT and AVRT

Pathophysiological mechanism of AVNRT
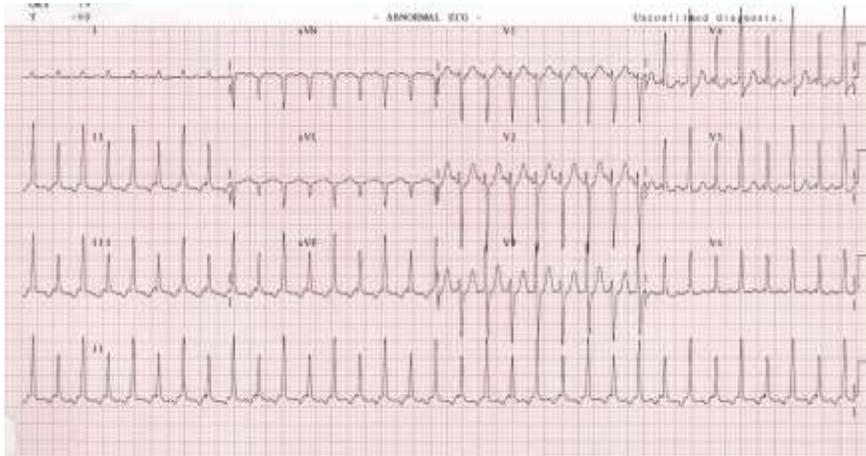

Pathophysiological mechanism of AVRT
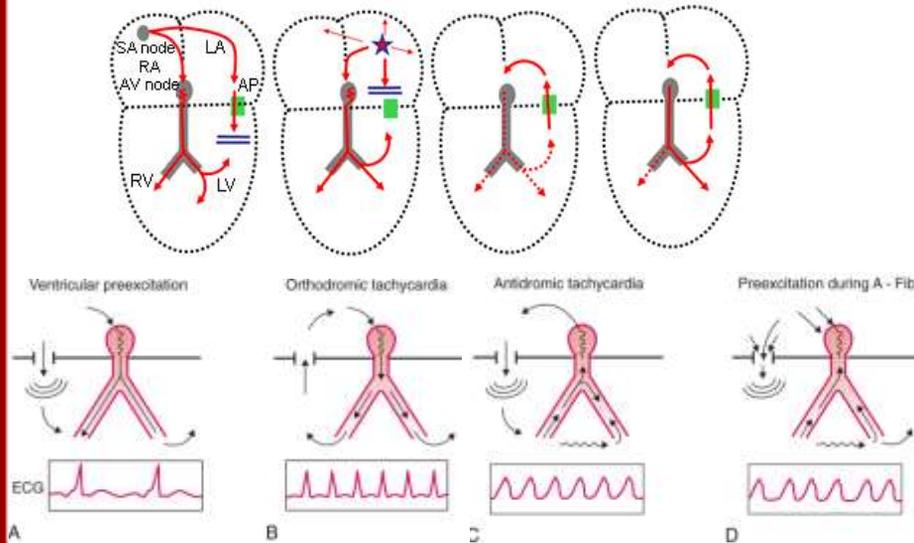
- **Pseudo-s** & **Pseudo-q** in inferior Leads.
- **Pseudo-r**$^{/}$ in V1.

- **aVL notch:** any positive deflection at the end of the QRS during SVT and its absence during SR.

SVT   SR
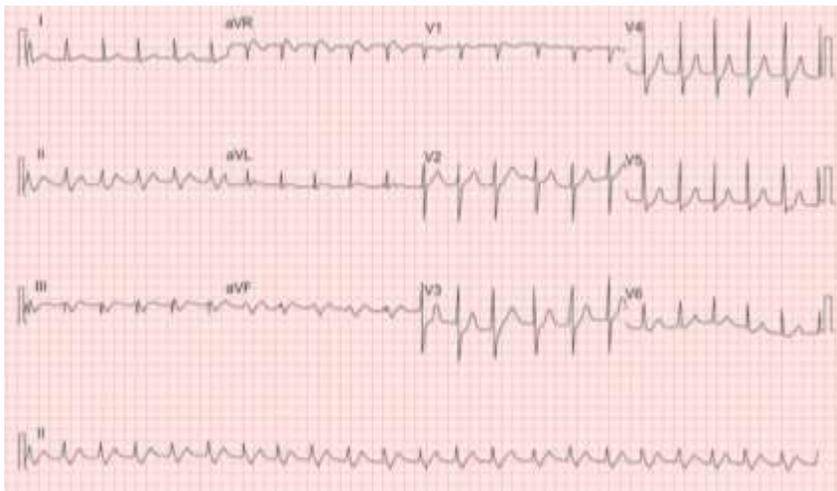
Di Toro D et al. *Europace* 2009; 11(7): 944-948

- **QRS alternans:** a beat to beat variation in the QRS amplitude in any one or more parts of the ECG without evidence of low voltage.

- **ST elevation in aVR**
    - AVNRT → retrograde atrial activation occurred concentrically.
    - AVRT → retrograde atrial activation occurred eccentrically → ↑ ST aVR

Ho YL et al. *Am J Cardiol* 2003; 92: 1424-1428

Favors AVNRT

Pseudo-r' wave in V_1
Pseudo-s wave in inferior leads
Pseudo-q wave in inferior leads
Absence of positive ECG findings
Notch in aVL lead

RP interval analysis: <70 ms
Response to ATP test

Favors AVRT

Visible retrograde P wave
QRS alternans
ST-segment elevation in aVR
Marked repolarization changes in tachycardia
Lengthening of the tachycardia cycle length when bundle branch
   block occurs ipsilateral to the accessory pathway
RP interval >70 ms
Response to ATP test

Gonzalez-Torrecilla E et al. *Ann Noninvasive Electrocardio.* 2011; 16(1): 85-95
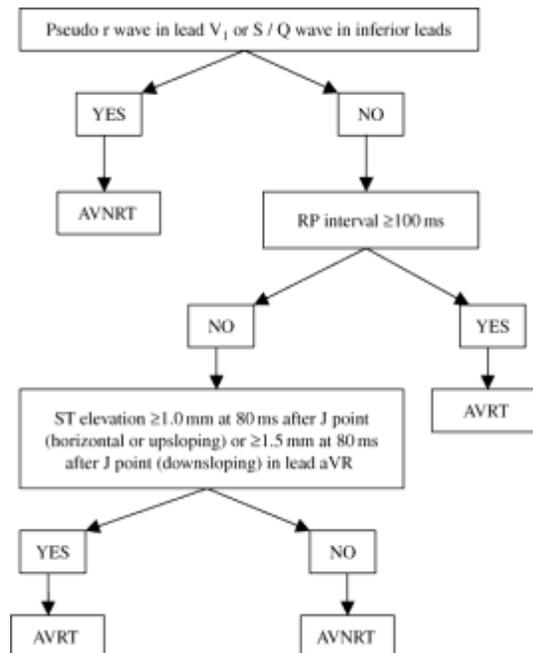
Zhong YM et al. *Int J Clin Pract* 2006; 60(11): 1371-1377

ECG in Atrial Flutter

- Atrial rates of 250-350 beats/min.
- Monomorphic P waves without isoelectric baseline (sawtooth pattern)
- Some degree of atrioventricular node conduction block.
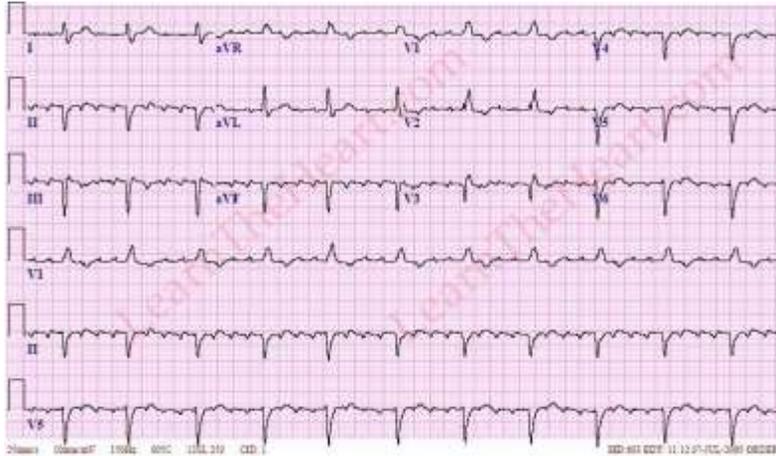
Typical Atrial Flutter:

- Activation anticlockwise around TV annulus
- Negative flutter waves in leads II, III, and aVF
- upright flutter waves in lead V1

Atypical Atrial Flutter:

- Activation clockwise around TV annulus
- Positive flutter waves in leads II, III, and aVF
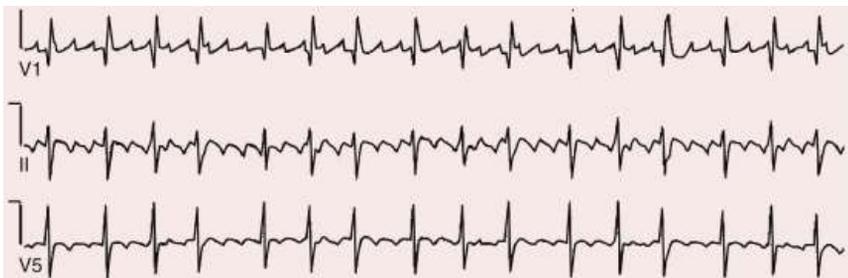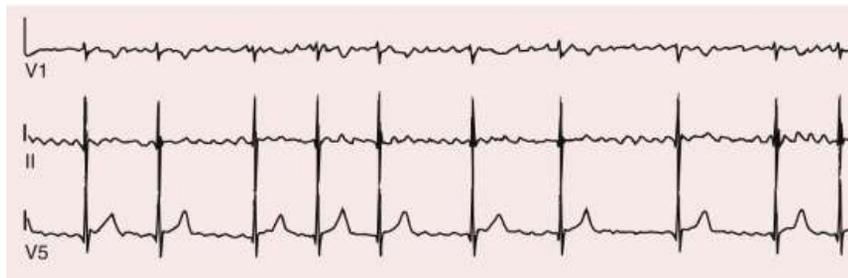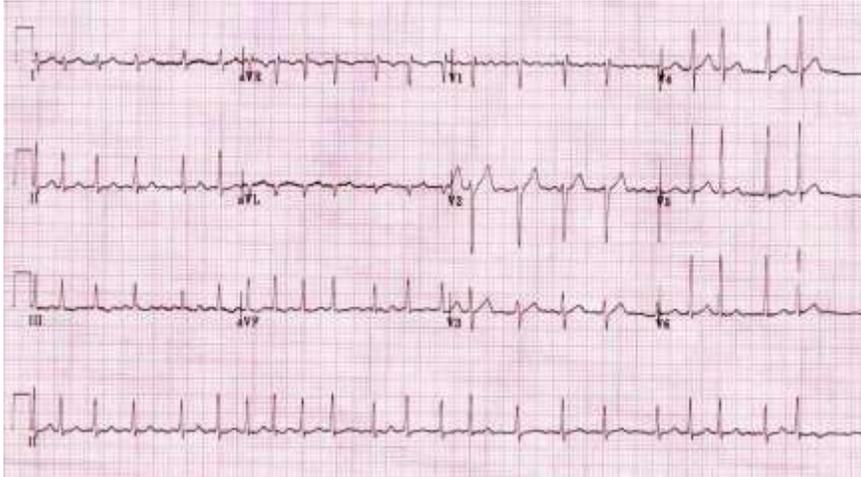- Negative flutter waves in lead V1

Oblique view of right atrium
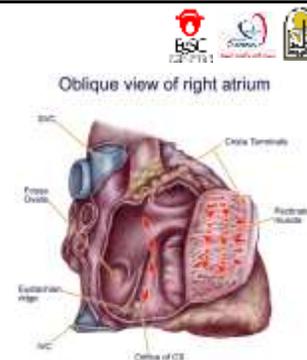
Negative flutter waves II, III, aVF
Counterclockwise flutter

Positive flutter waves II, III, aVF
Clockwise flutter

ECG in Atrial Fibrillation (AF)

- No visible P wave or rapid oscillating fibrillatory waves (f wave).
- Irregular irregulatory QRS complex.

ECG in Multifocal atrial tachycardia (MAT)

- A rapid, irregular atrial rhythm from multiple foci within the atria.
- Ventricular rate > 100 beats/min.
- Has at least 3 different P wave morphology.
- Irregular P-P interval.
- Isoelectric baseline between P-waves (i.e. no flutter waves).

Aim for any case of cardiology