Webinar – 13th November 2025, Module 2

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Essential ECGs

ECGs that matter

Moderator: Adele Greyling

Rob Scott Millar & Ashley Chin
University of Cape Town / Groote Schuur Hospital
Cape Town, South Africa

Summary

- Approach to ECG analysis
  - Overview
  - Rate, rhythm (regular or irregular), QRS width
  - Systematic analysis
- Examples of essential ECGS (Module 1)
  1. Normal
  2. Complete heart block
  3. Mobitz II 2nd degree AV block
  4. Inferior and anterior ST elevation myocardial infarction
  5. Atrial fibrillation
  6. Right bundle branch block
  7. Left bundle branch block
- This module: 7 more ECGs

- Free download
- The app was developed by Dr Charle Viljoen of UCT, with help from Rob Scott Millar and many others.
- A teaching and reference tool.
- You will find answers to a lot of your questions in this app
- The app has been redesigned and updated.
- The new version includes searchable terms and clinical correlations
- Available in English, French, German, Portuguese and Spanish.
- More than 32,000 downloads within days of release

Free app for download

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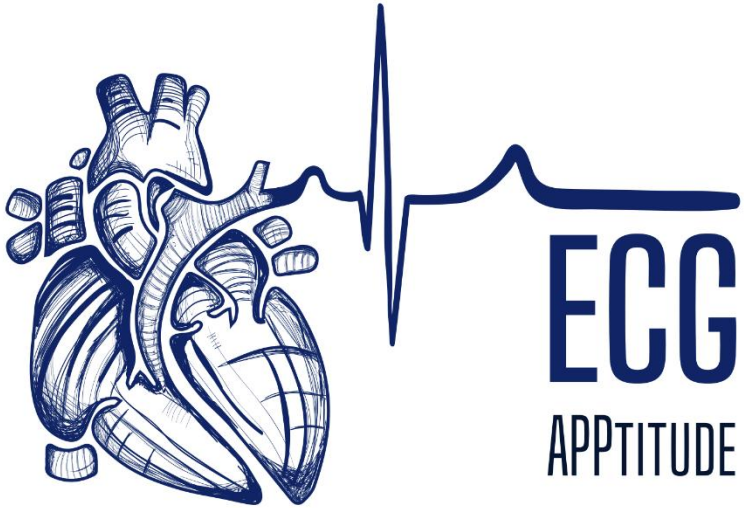

ECG
APPTITUDE

GET IT ON Google Play

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Comprehensive ECG reference guide, with diagnostic approaches for arrhythmias and abnormal waveforms

What can you learn from an ECG?

- Rhythm
- Conduction
- Structural heart disease
  - Myocardial infarction
  - Hypertrophy
    - Atria
    - Ventricles
  - Pericarditis
- Transient abnormalities
  - Ischaemia
  - Electrolytes

Who should have an ECG?

- Acute chest pain
- Arrhythmia
- Suspected heart disease
- Chest pain
- Unexplained blackouts
- Hypertension
- Major medical/surgical illness
- Drug overdose
- Stroke
- Patients over 50
- Routine check up

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Looking at the ECG

Primary observations

- Ventricular rate:
  - Normal (60 – 100/minute)
  - Slow (<60/minute)
  - Fast (>100/minute)
- Regularity:
  - Regular
  - Irregular
- QRS width
  - Normal (≤100ms)
  - Wide (≥120ms)
    - Left bundle branch block
    - Right bundle branch block
    - Neither
    - Delta wave

Secondary observations

- P waves
  - Present or absent/not visible
  - Morphology (? Upright in II, negative aVR)
  - Rate
  - Relationship to QRS complexes
- PR interval
- QRS abnormalities
- ST segments
- T waves
- QT interval

You see only what you look for
You recognise only what you know

(Merrill C Sosman - Radiologist 1890-1959)

MERRILL CLARY SOSMAN, M.D.

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Steps in analysing the ECG

- **Observe and measure**
  - Rate
  - Regularity
  - QRS width
  - Any obvious abnormalities
- **Systematic analysis**
  - P waves
  - PR interval
  - QRS complexes
  - ST segments
  - T waves
  - QT

- **Interpret**
  - Normal/abnormal
  - Possible mechanisms of abnormalities
  - Consider the differential diagnosis
  - Exclude the impossible
- **Conclude**
  - Rhythm
  - Structural abnormalities
  - Alternative diagnoses
  - Possible underlying pathology

Summarise

Main features
Likely diagnosis

Communicate

your findings clearly and succinctly

Beware snap ("blink") diagnoses and hasty conclusions which lead to premature closure

Look beyond the obvious – analyse systematically

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What is a normal ECG?

- Normal sinus rhythm
- Normal PR interval
- QRS normal
  - Duration
  - Size
  - Axis
  - No pathological q waves
- Normal ST segments and T waves
- Normal QT interval
- Minor deviations usually benign

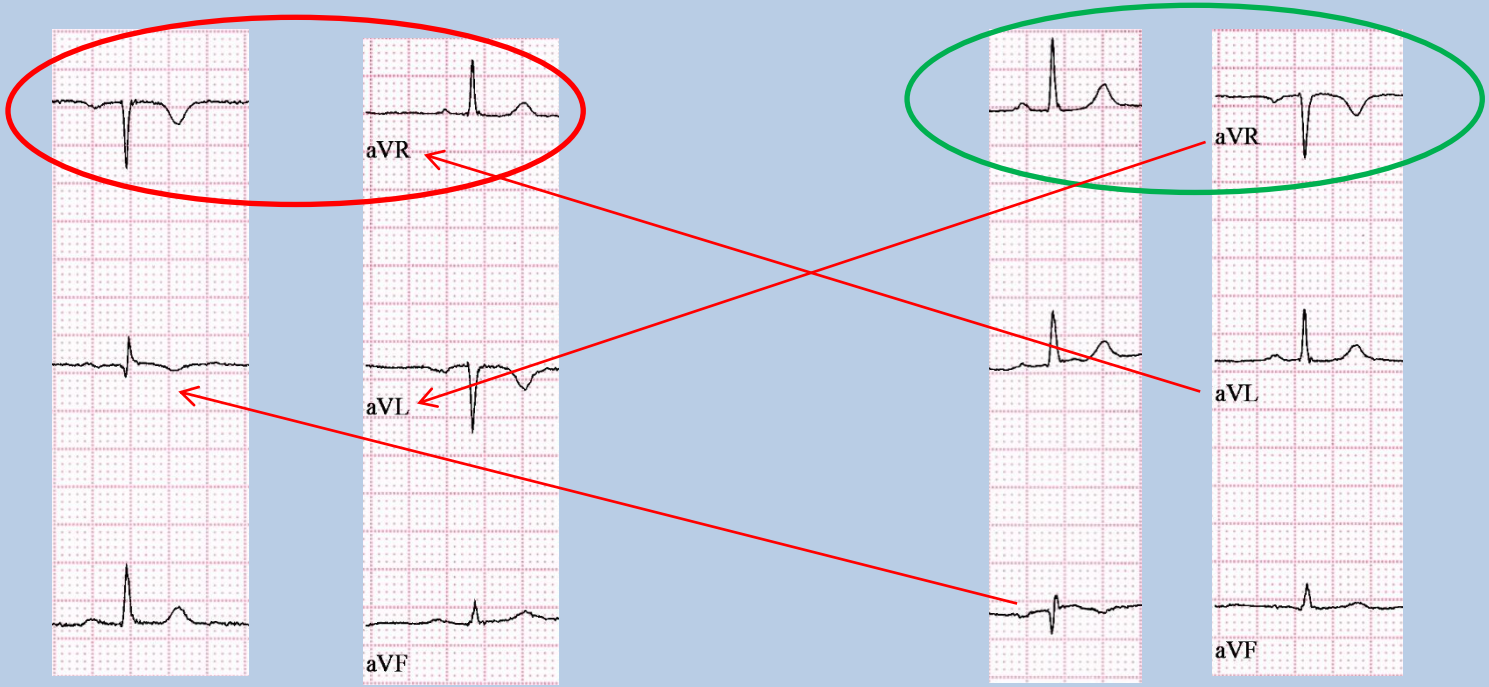
Normal Adult ECG values

- P wave
  - Axis: +30^{o} to +70^{o} (+ve II, -ve aVR)
  - Duration ≤ 110ms
- PR interval:
  - 120 to ≤ 200ms (3-5 small blocks)
- QRS
  - Duration: ≤ 100ms (≤ 2.5 small blocks)
  - Axis: +0^{o} to +90^{o} (0^{o} to -30^{o} grey zone)
  - Size: S in V1 + R in V5/V6 ≤ 3.5mV (35mm)
    - R in aVL ≤ 1.1mV (11mm)
- QTc
  - ≤ 440ms (males)
  - ≤ 460ms (females)

Incorrect lead placement

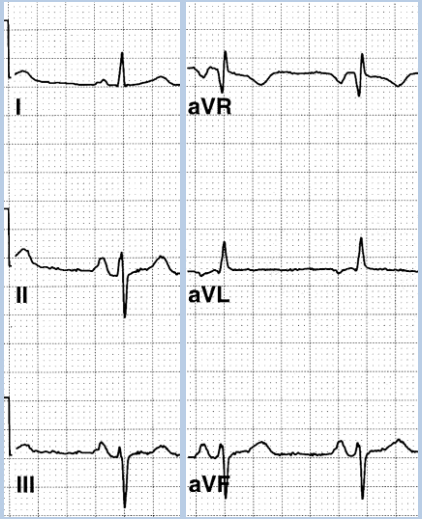
Left-right arm leads reversed

Leads correct



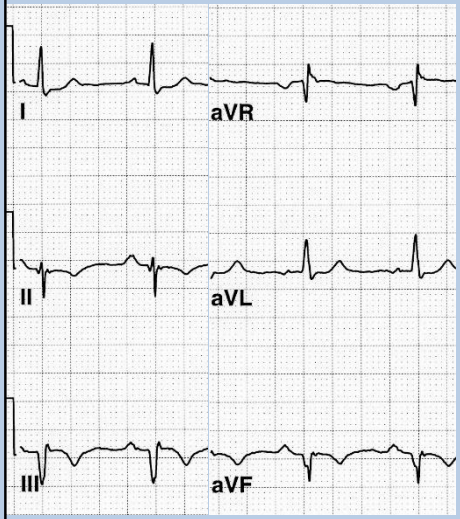
Mechanisms of left axis deviation

Left anterior fascicular block



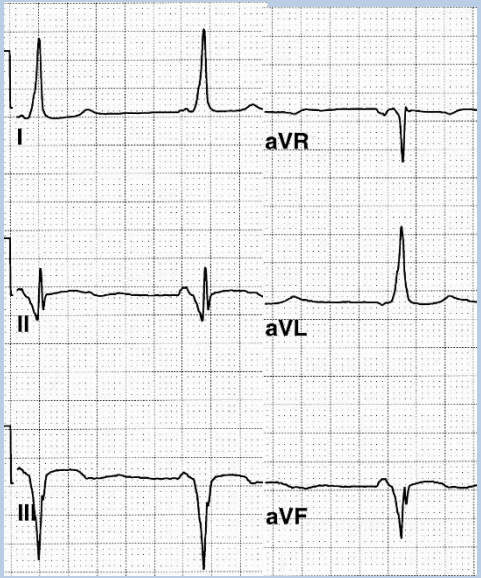
- QRS axis -50° (< -30°)
- Small r waves II, III, aVF
- Small q waves I, aVL
- QRS width normal
- Terminal S waves II, III, aVF

Old inferior myocardial infarction



- QRS axis -50°
- Broad (≥30ms) q waves II, III, aVF
- Terminal r waves II, III, aVF

Wolff-Parkinson-White pattern



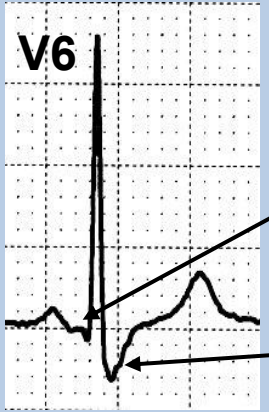
- QRS axis -40°
- Short PR interval – 100ms
- Wide QRS – 140ms
- Initial slurred delta wave – negative in II, III, aVF – simulates inferior MI

Typical patterns of right & left bundle branch block

RBBB

V1 & V2 positive
rSR' in V1

Broad *terminal* R in V1

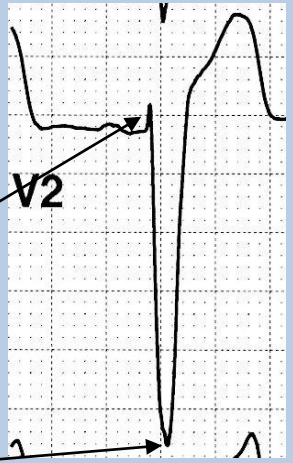


Normal left ventricular activation (septal q, rapid R upstroke in V6)

Small, broad terminal s in V6

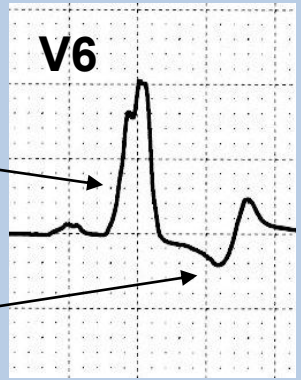
LBBB

V1 & V2 negative
V5 & V6 positive



Initial *sharp* deflection V1 & V2 (< 40 ms)

Onset to nadir of S wave < 70ms



Slurred R wave

Absent septal q wave

Inverted T wave

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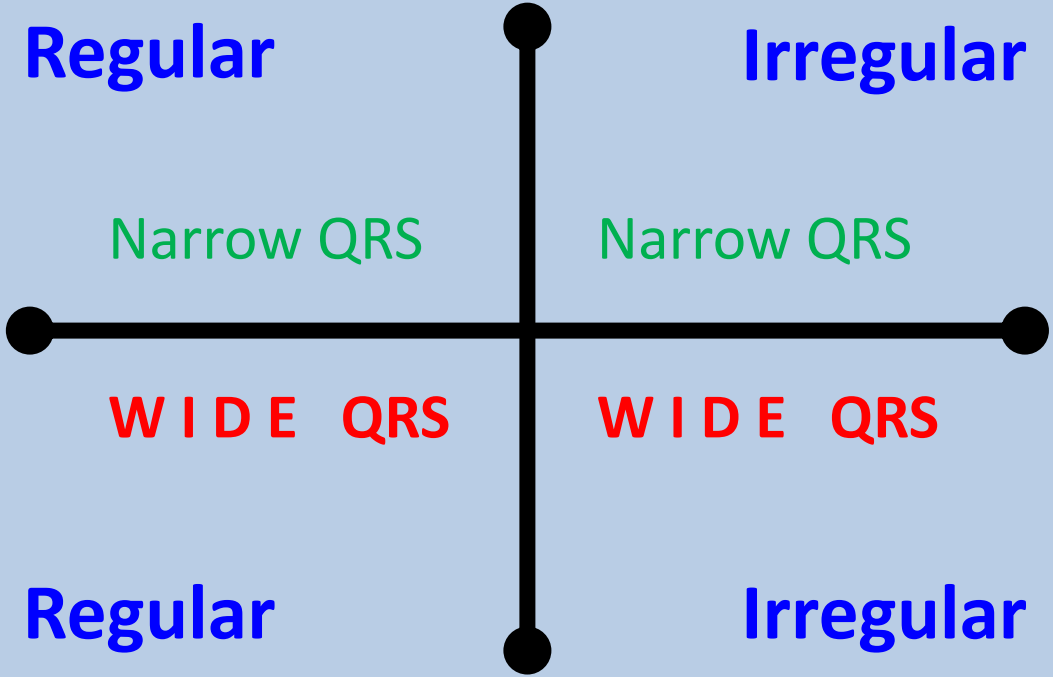
TACHYARRHYTHMIAS



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TACHYARRHYTHMIAS

Regular

Narrow QRS

- Sinus tachycardia
- **Atrial flutter**
- **AV nodal re-entry tachycardia**
- Atrioventricular re-entry tachycardia (WPW)
- Atrial tachycardia
- Junctional ectopic tachycardia

Irregular

Narrow QRS

- **Atrial Fibrillation**
- **Atrial flutter/tachy + variable AV block**
- Multifocal atrial tachycardia

W I D E QRS

Regular

- **Ventricular tachycardia**
- SVT with bundle branch block
- SVT with non-specific intraventricular conduction delay
- Antidromic AV re-entry tachycardia } WPW
- Pre-excited SVT
- Paced rhythm

W I D E QRS

Irregular

- **AF with BBB**
- **A flutter/tachy + variable AV block + BBB**
- Pre-excited AF (WPW)
- Polymorphic VT
- Repetitive monomorphic VT

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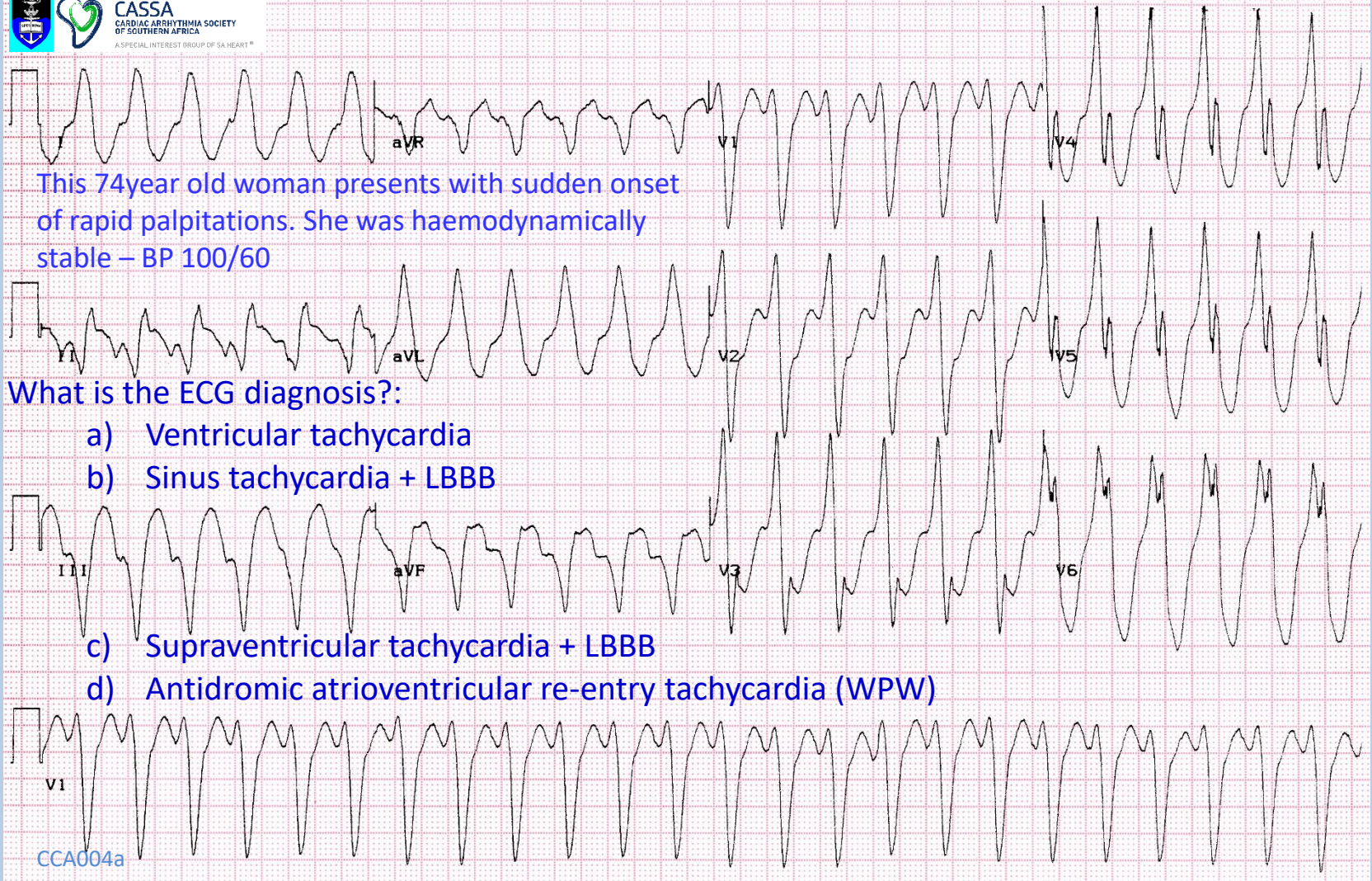
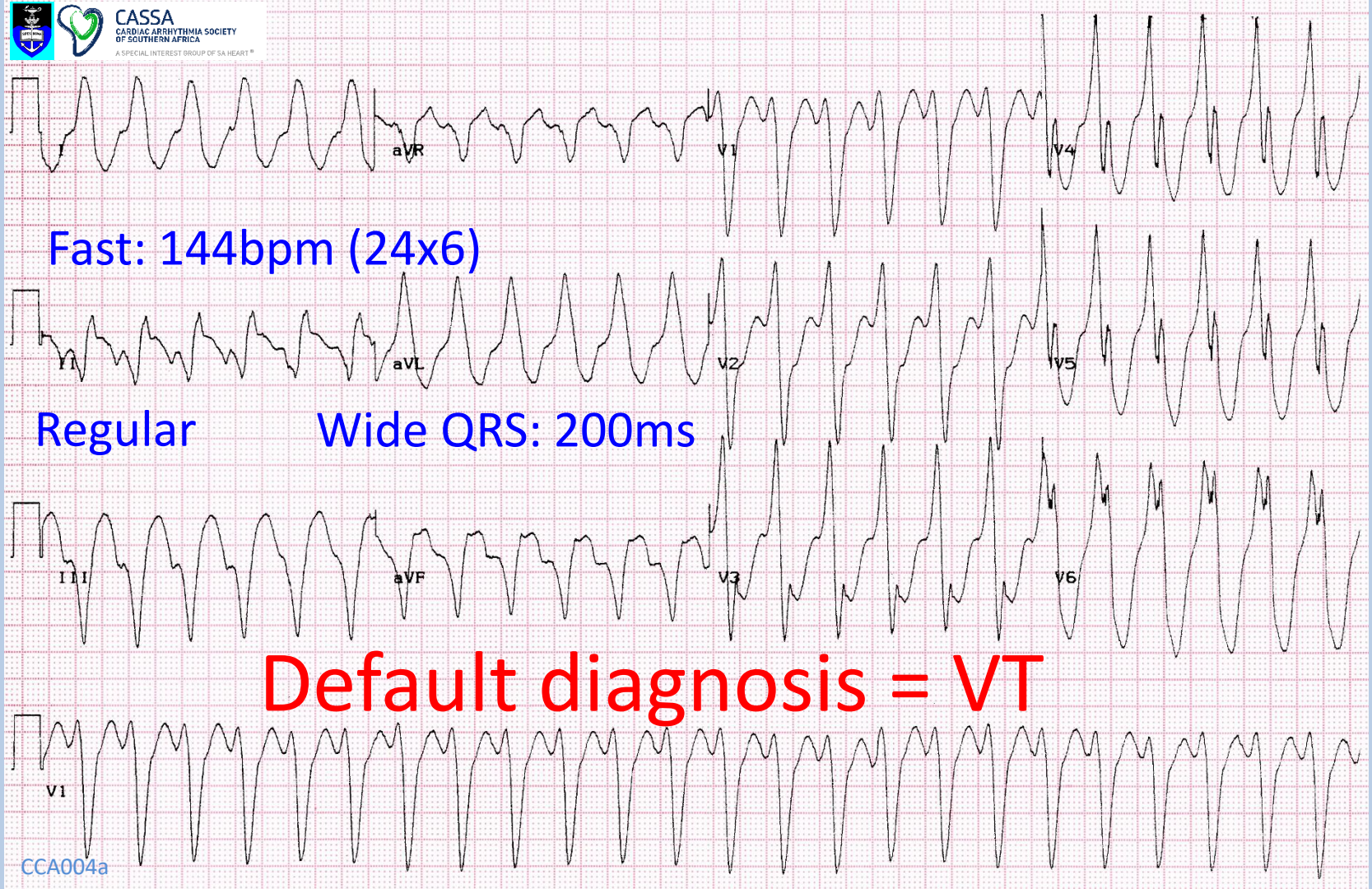


This 74year old woman presents with sudden onset of rapid palpitations. She was haemodynamically stable – BP 100/60

What is the ECG diagnosis?:

a) Ventricular tachycardia
b) Sinus tachycardia + LBBB
c) Supraventricular tachycardia + LBBB
d) Antidromic atrioventricular re-entry tachycardia (WPW)

CCA004a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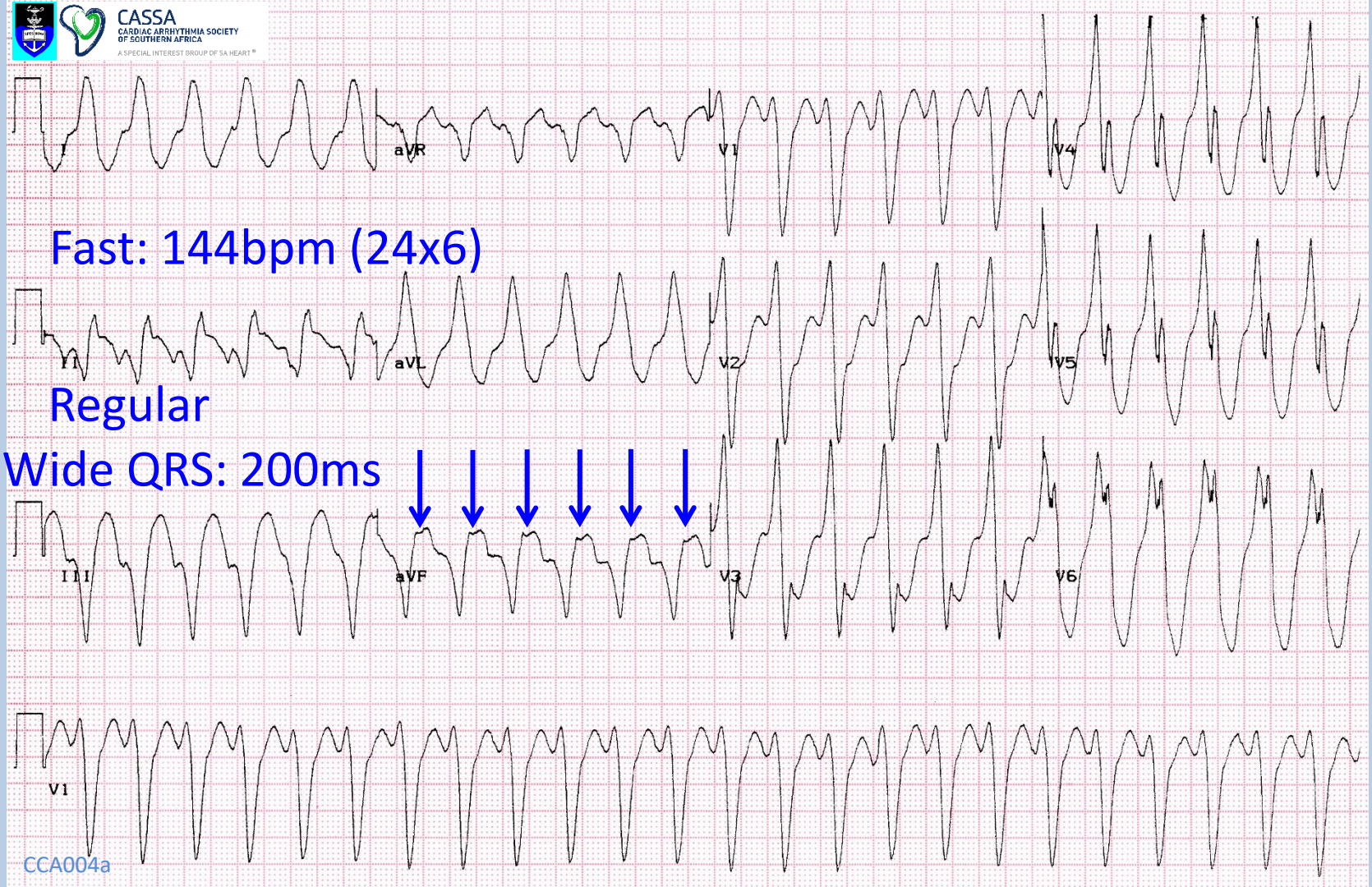
I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
V1
Fast: 144bpm (24x6)
Regular
Wide QRS: 200ms
Default diagnosis = VT
CCA004a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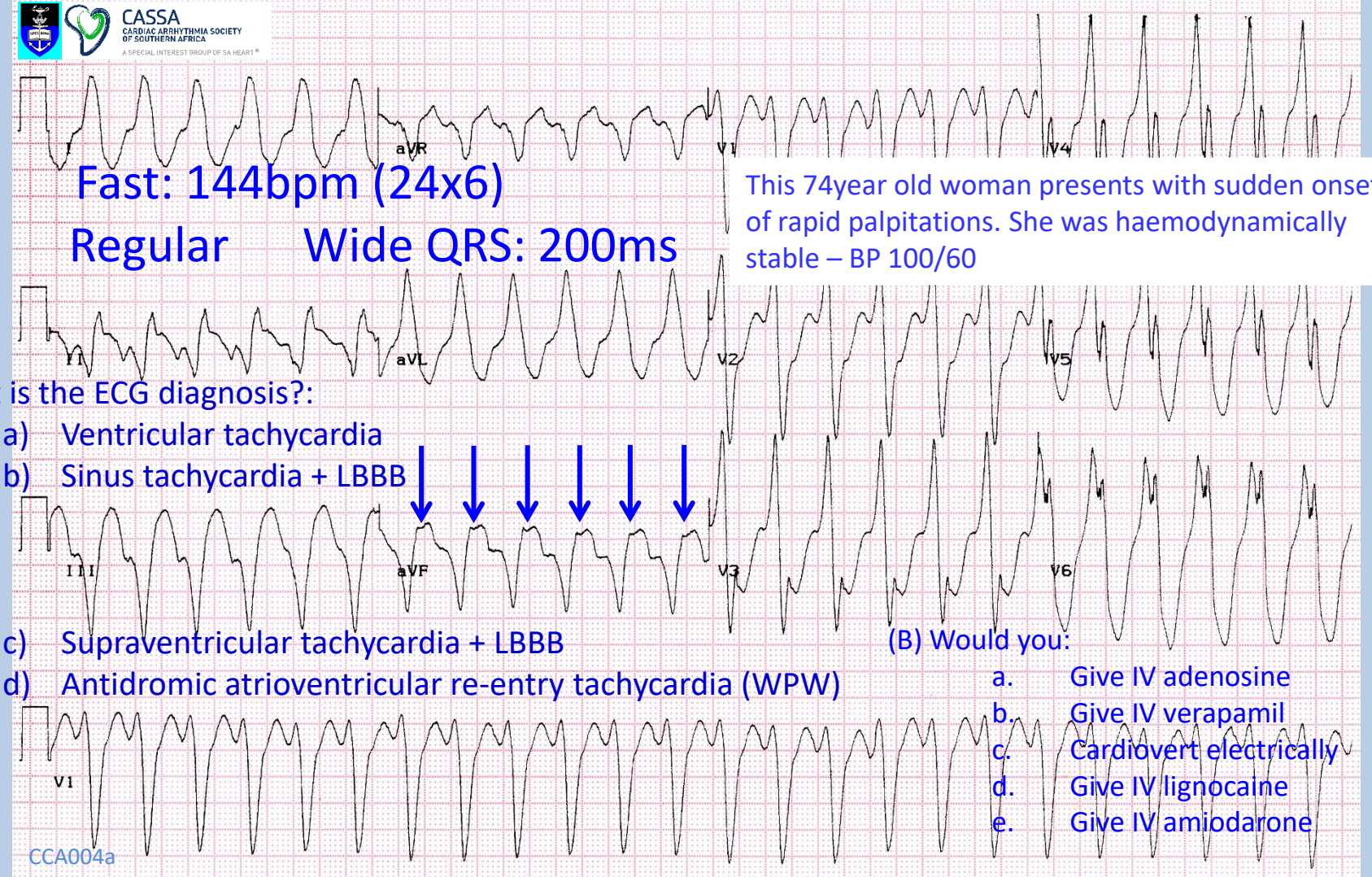


Fast: 144bpm (24x6)

Regular Wide QRS: 200ms

This 74year old woman presents with sudden onset of rapid palpitations. She was haemodynamically stable – BP 100/60

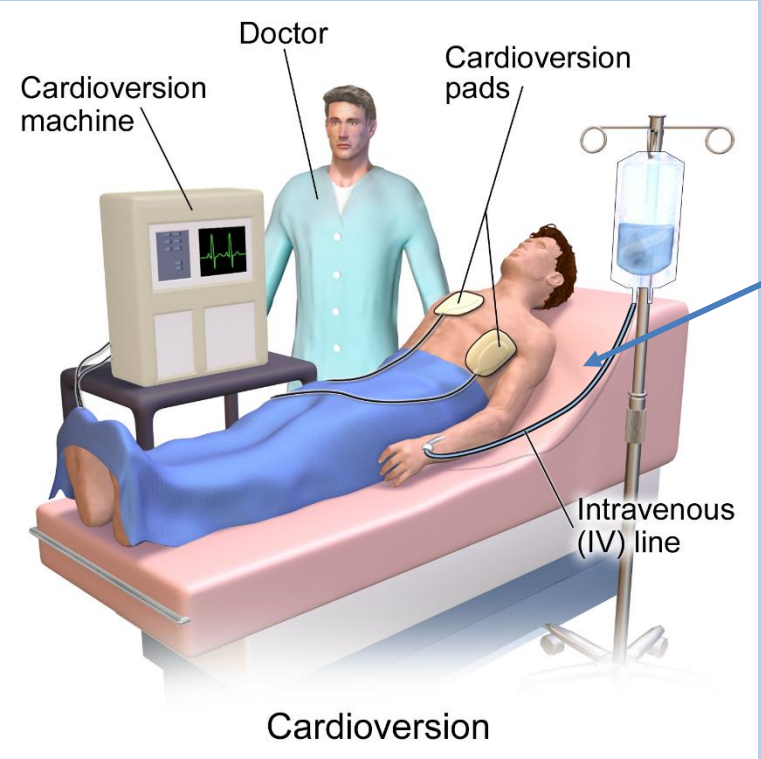
What is the ECG diagnosis?:

a) Ventricular tachycardia
b) Sinus tachycardia + LBBB
c) Supraventricular tachycardia + LBBB
d) Antidromic atrioventricular re-entry tachycardia (WPW)

(B) Would you:

a. Give IV adenosine
b. Give IV verapamil
c. Cardiovert electrically
d. Give IV lignocaine
e. Give IV amiodarone

Synchronised DC cardioversion



Wikipedia: Blausen.com staff (2014). "Medical gallery of Blausen Medical 2014"

- Resuscitation equipment
- Reassure the patient
- Consent
- Set up
- Check synchronisation to R wave
- Midazolam IV until patient is asleep
- Check patient's airway/breathing
- Set power to 150J/200J (biphasic shock)
- Start recording ECG (preferably 3 channels)
- Recheck synchronisation
- Deliver shock
- Check ECG rhythm and vital signs
- Do 12 lead ECG

(B) Would you:

a. Give IV adenosine
b. Give IV verapamil
c. Cardiovert electrically
d. Give IV lignocaine
e. Give IV amiodarone

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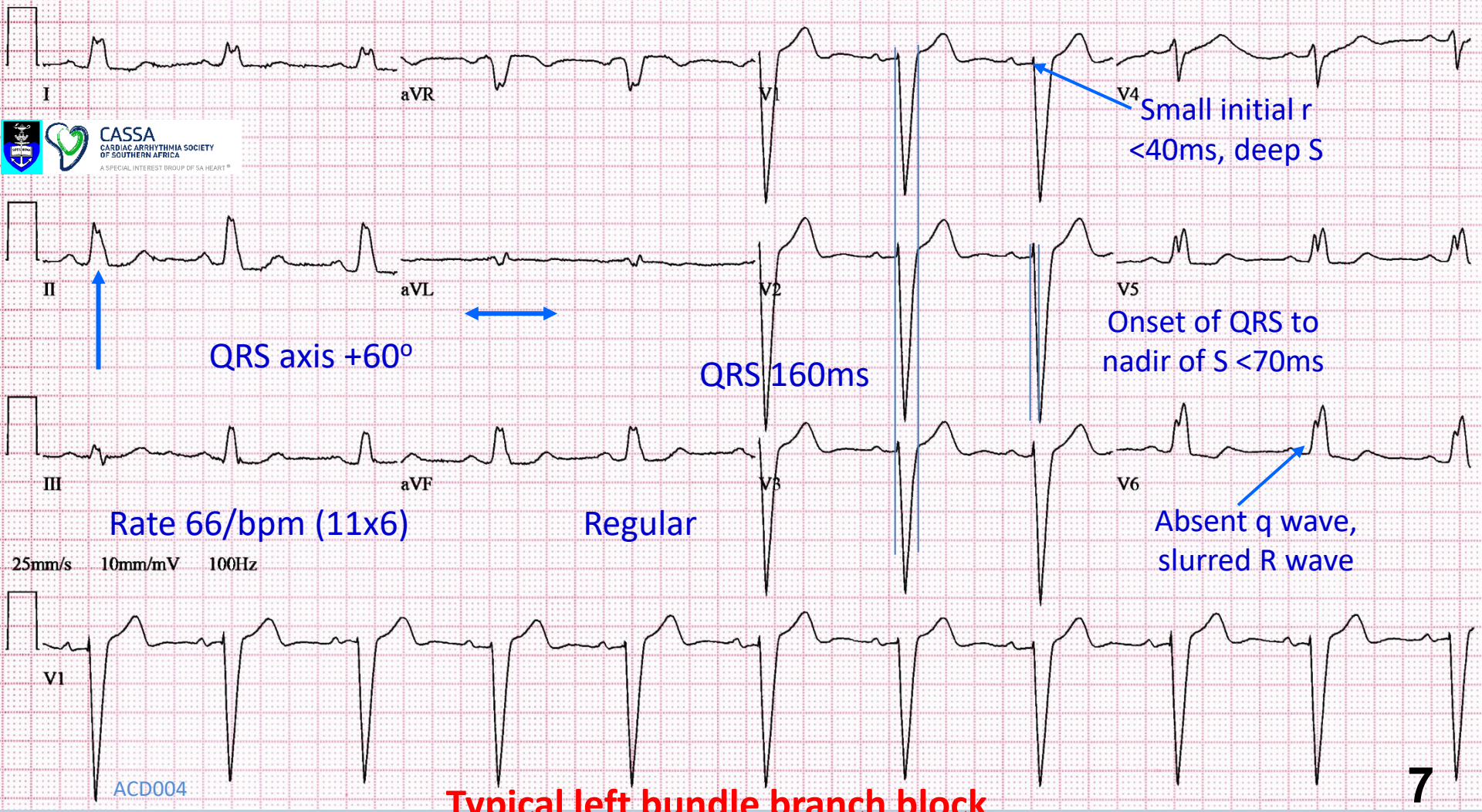
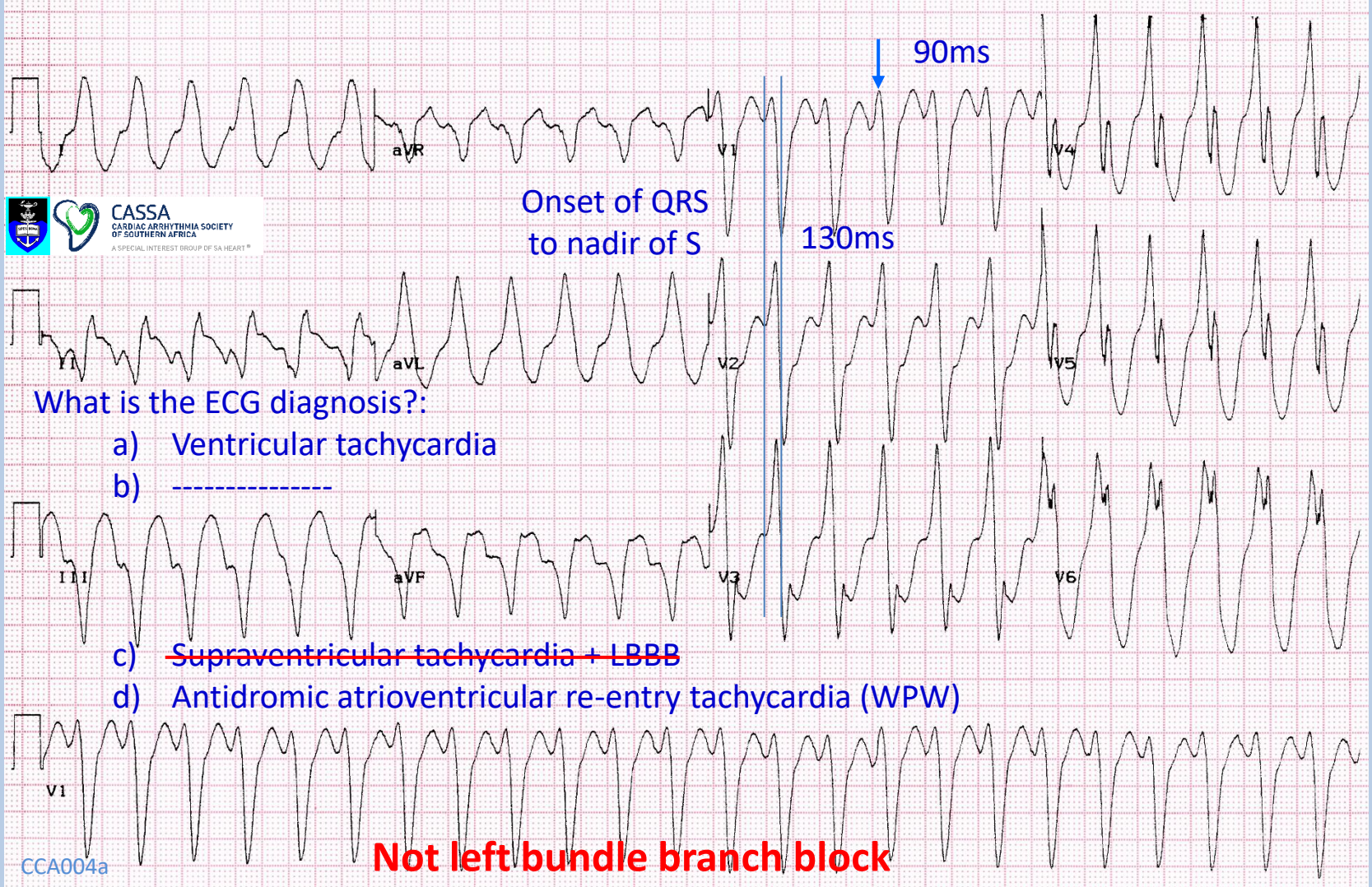


Typical left bundle branch block



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What is the ECG diagnosis?:

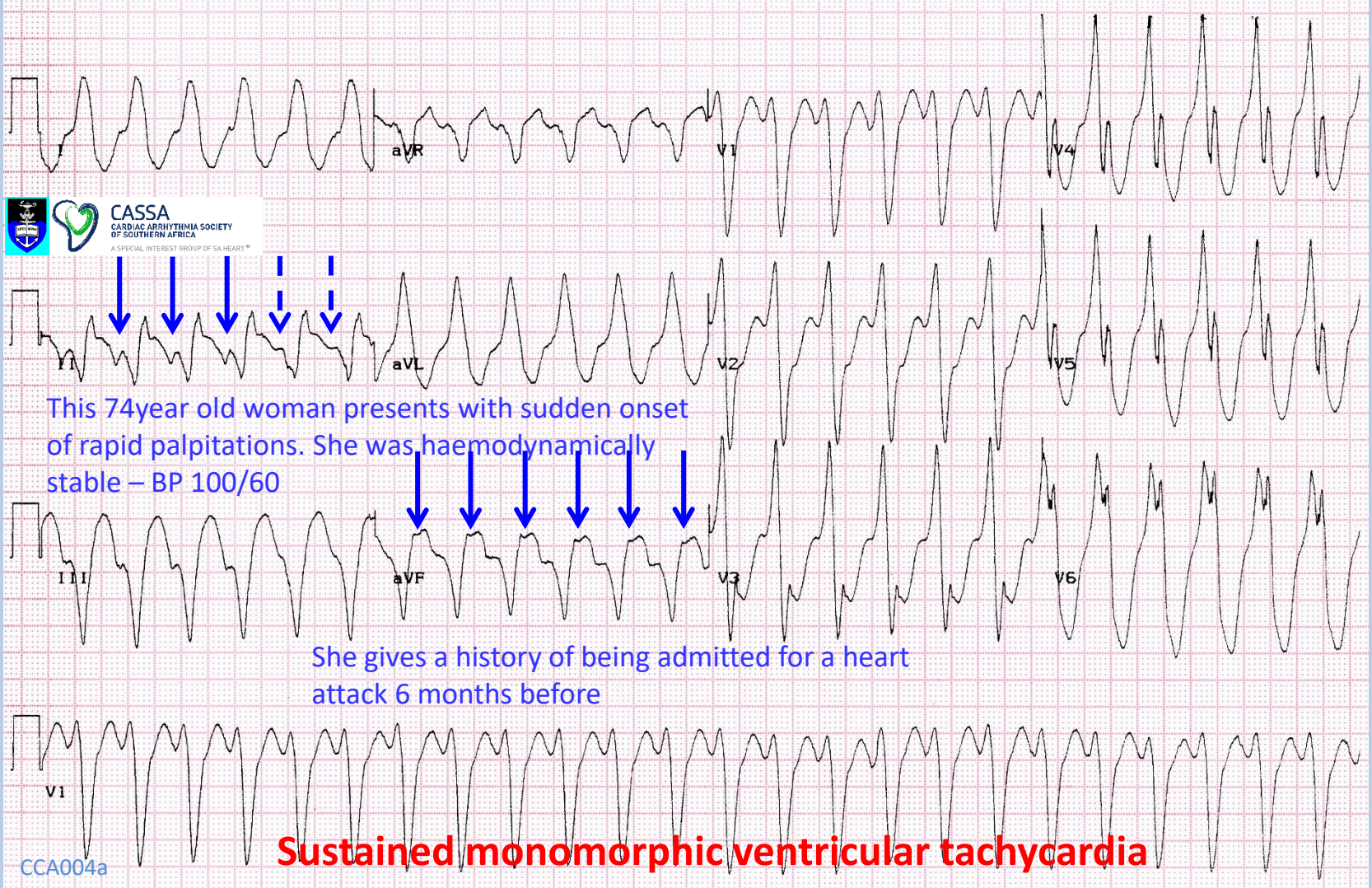
a) Ventricular tachycardia

b) ----------

c) ~~Supraventricular tachycardia + LBBB~~

d) Antidromic atrioventricular re-entry tachycardia (WPW)

Not left bundle branch block



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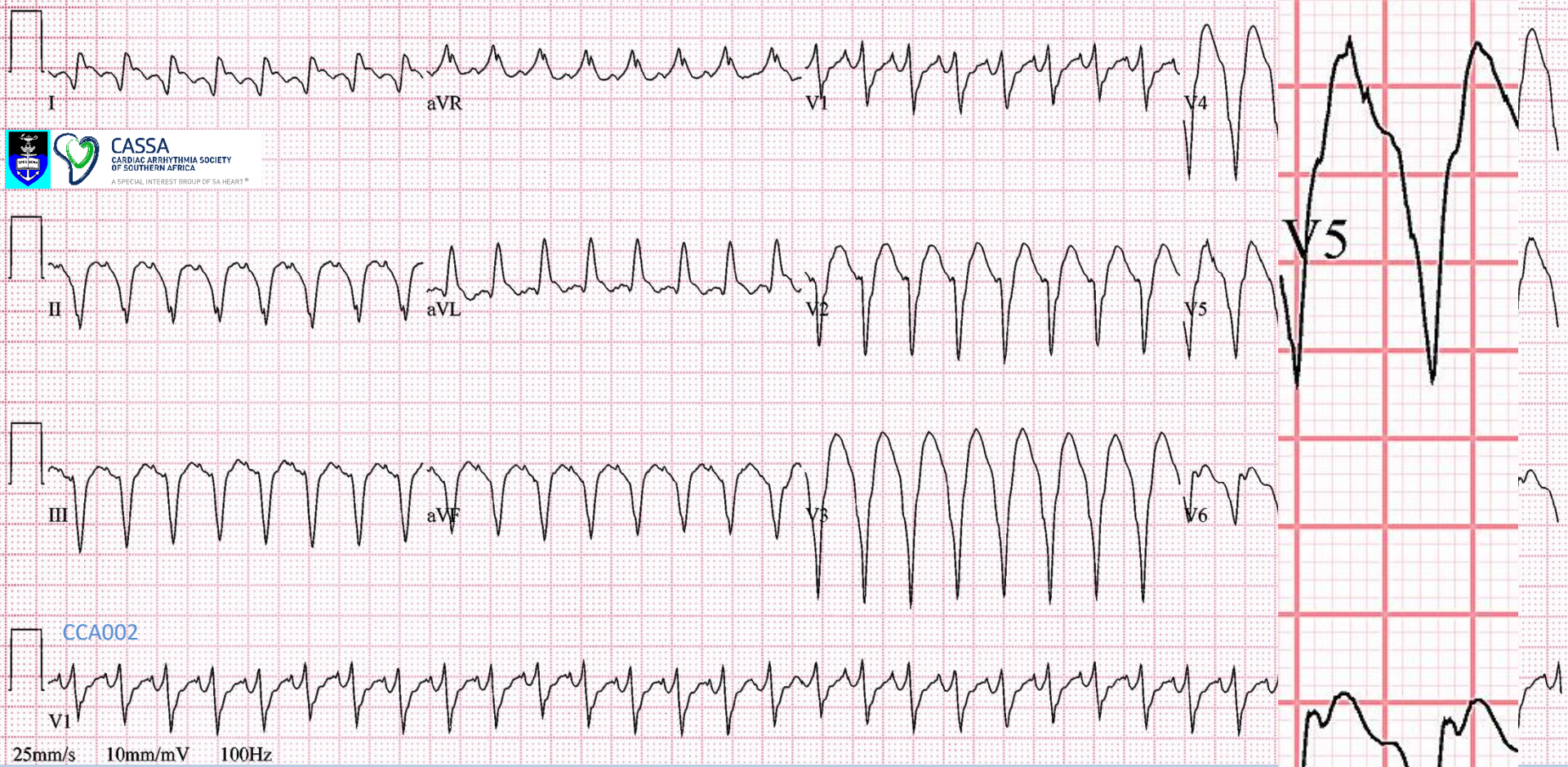
This 74year old woman presents with sudden onset of rapid palpitations. She was haemodynamically stable – BP 100/60

She gives a history of being admitted for a heart attack 6 months before

Sustained monomorphic ventricular tachycardia

CCA004a



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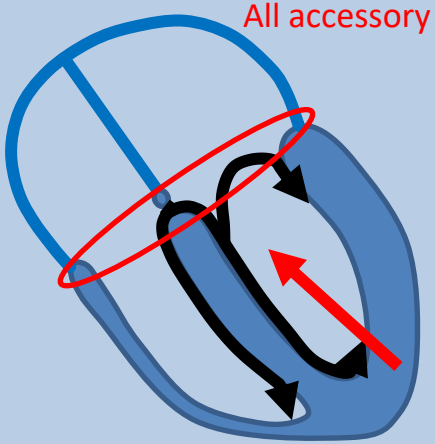
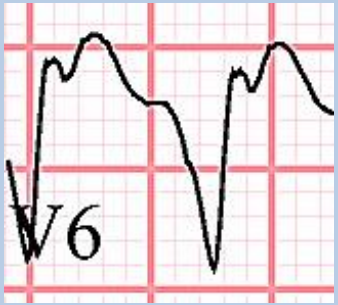
CCA002

Ventricular tachycardia or antidromic AVRT how do we differentiate?

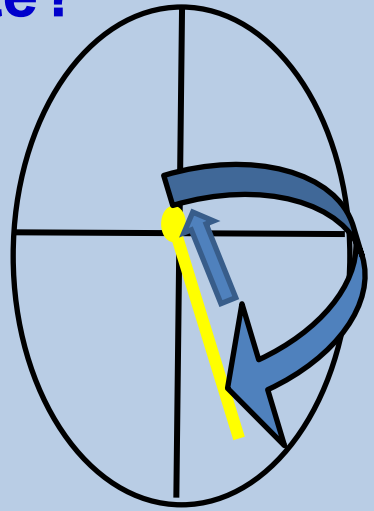
- ECG features:
  - AV dissociation: if present, it excludes AVRT, confirms VT
  - QS pattern V4-V6 – excludes AVRT

All accessory pathways insert around the AV ring





V6



Antidromic AVRT (uncommon)
There must be a 1:1 AV relationship

- If neither, it may be impossible to differentiate on ECG alone

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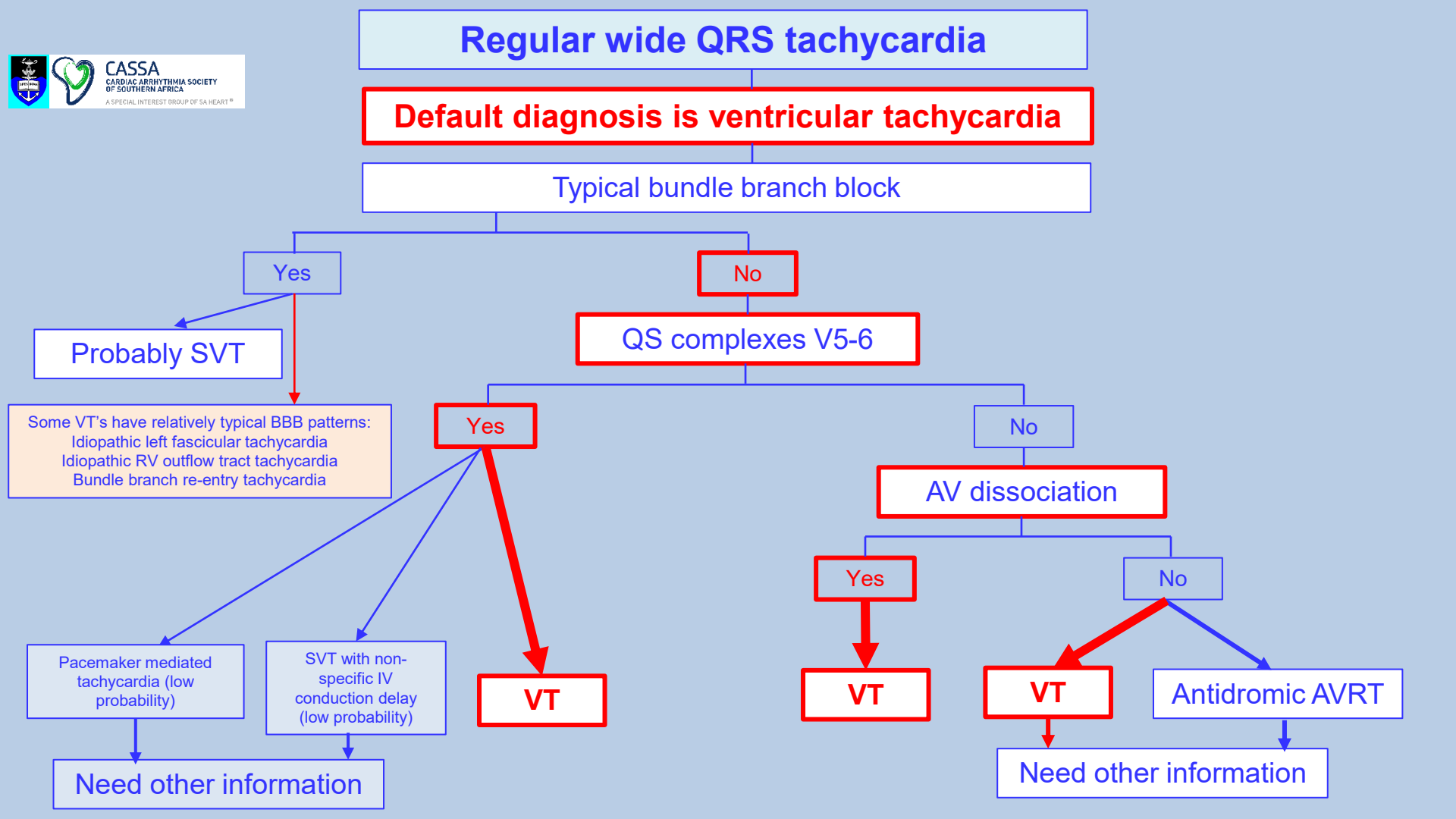
Regular wide QRS tachycardia
Default diagnosis is ventricular tachycardia
Typical bundle branch block
Yes
No
Probably SVT
Some VT's have relatively typical BBB patterns:
Idiopathic left fascicular tachycardia
Idiopathic RV outflow tract tachycardia
Bundle branch re-entry tachycardia
QS complexes V5-6
Yes
No
Pacemaker mediated tachycardia (low probability)
SVT with non-specific IV conduction delay (low probability)
VT
Need other information
AV dissociation
Yes
No
VT
VT
Antidromic AVRT
Need other information

Ventricular tachycardia or antidromic AVRT how do we differentiate?

- ECG features:
  - AV dissociation: if present, it excludes AVRT, confirms VT
  - QS pattern V4-V6 – excludes AVRT
  - If neither, it may be impossible to differentiate on ECG alone
- **Clinical context**
  - History of past MI – presence of substrate raises probability of VT to >95%
  - Age
    - Youth favours AVRT, but VT can occur from infancy to senility
  - Family history
- ECG in sinus rhythm
  - Delta waves confirm WPW
  - Pathological Q waves of old MI confirm VT, but beware pseudo-infarct patterns in WPW
  - Other: e.g. ARVC patterns, conduction problems (sarcoid)
- Other tachycardia ECGs
  - AV dissociation
  - Different QRS pattern favours VT

Regular wide QRS tachycardias

- **Ventricular tachycardia**
- **Supraventricular tachycardia with bundle branch block**
- Antidromic AVRT
  - WPW
  - Mahaim tachycardia
- Pre-excited SVT (e.g. atrial flutter)
- Ventricular paced rhythm
- SVT with nonspecific intraventricular conduction delay

Mechanisms of wide QRS complexes in tachycardias

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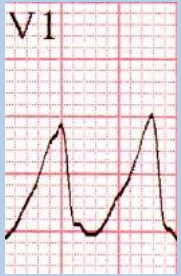
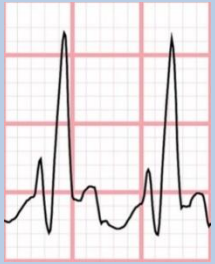
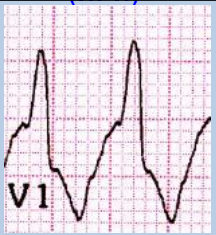
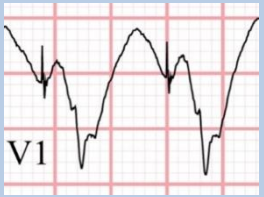
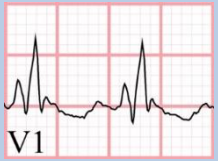
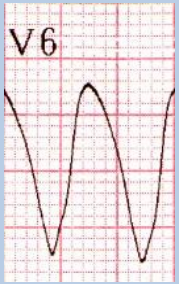
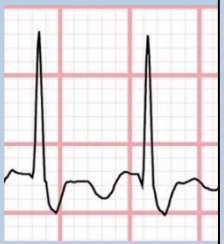
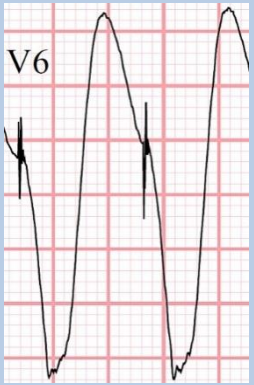
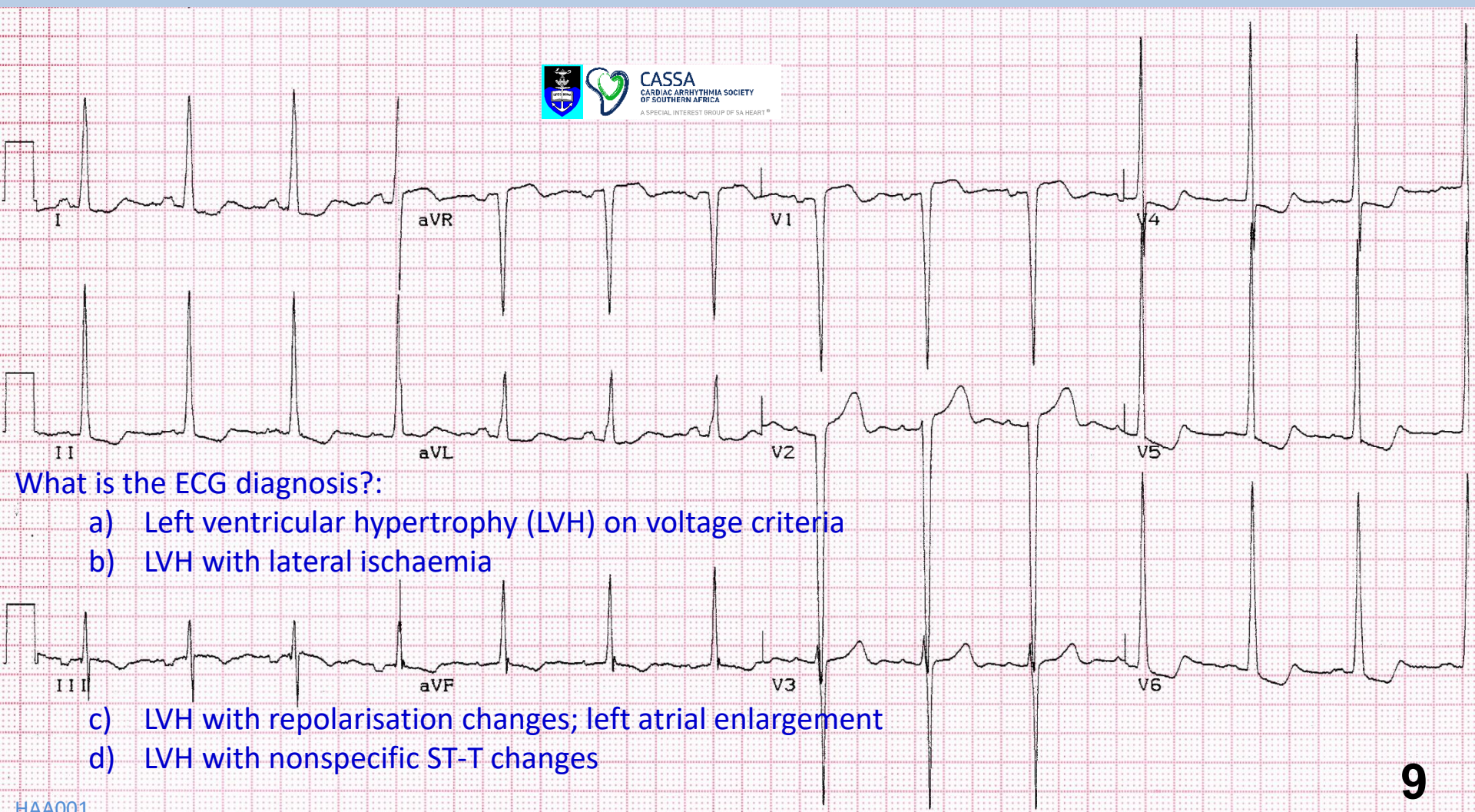
Ventricular origin	Supraventricular origin + RBBB	Supraventricular origin + LBBB	Supraventricular origin + pre-excitation (WPW)	Ventricular paced	Supraventricular origin + non-specific diffuse IVCD
					
					

QRS morphology is the key to diagnosis of wide QRS tachycardias



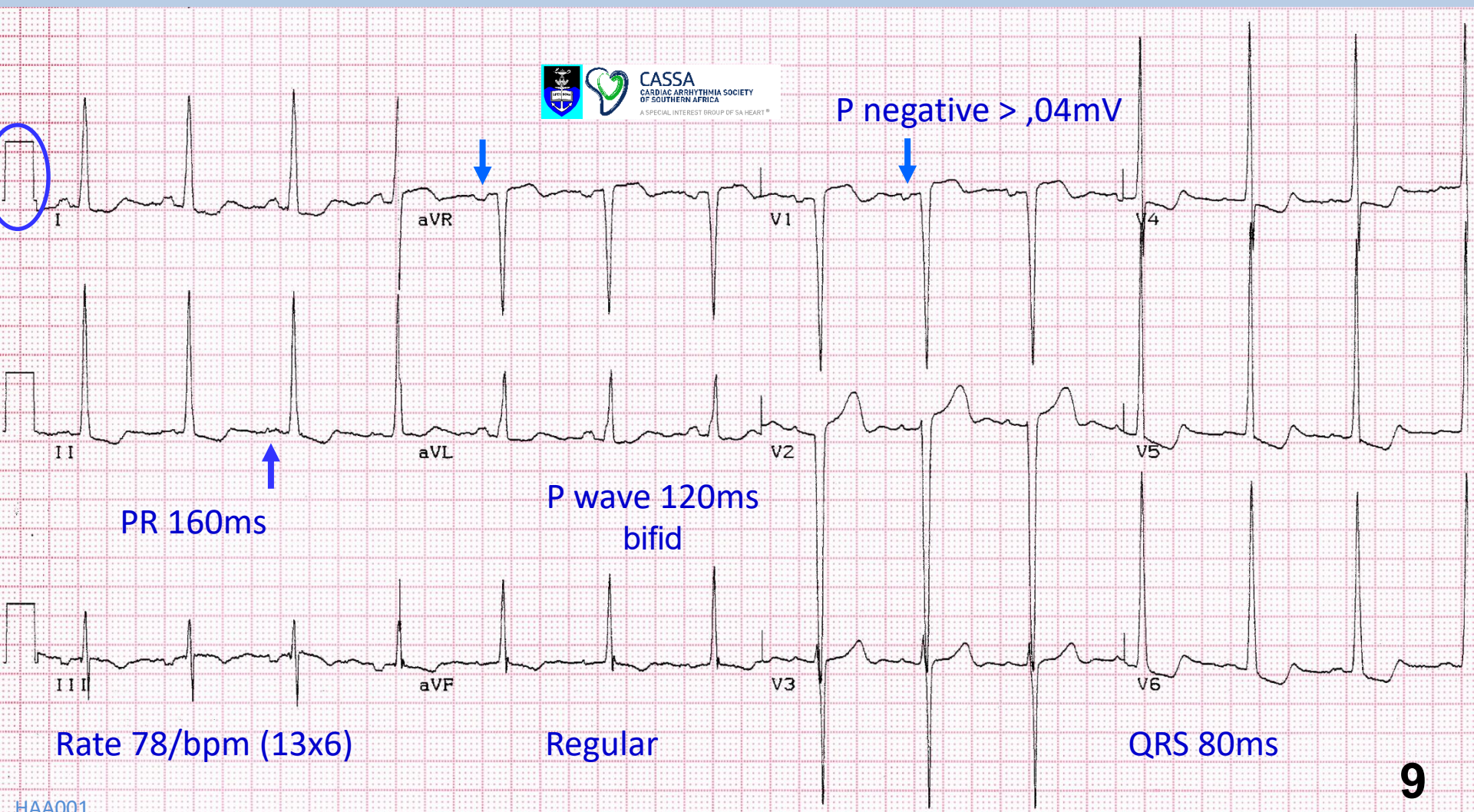
What is the ECG diagnosis?:

a) Left ventricular hypertrophy (LVH) on voltage criteria

b) LVH with lateral ischaemia

c) LVH with repolarisation changes; left atrial enlargement

d) LVH with nonspecific ST-T changes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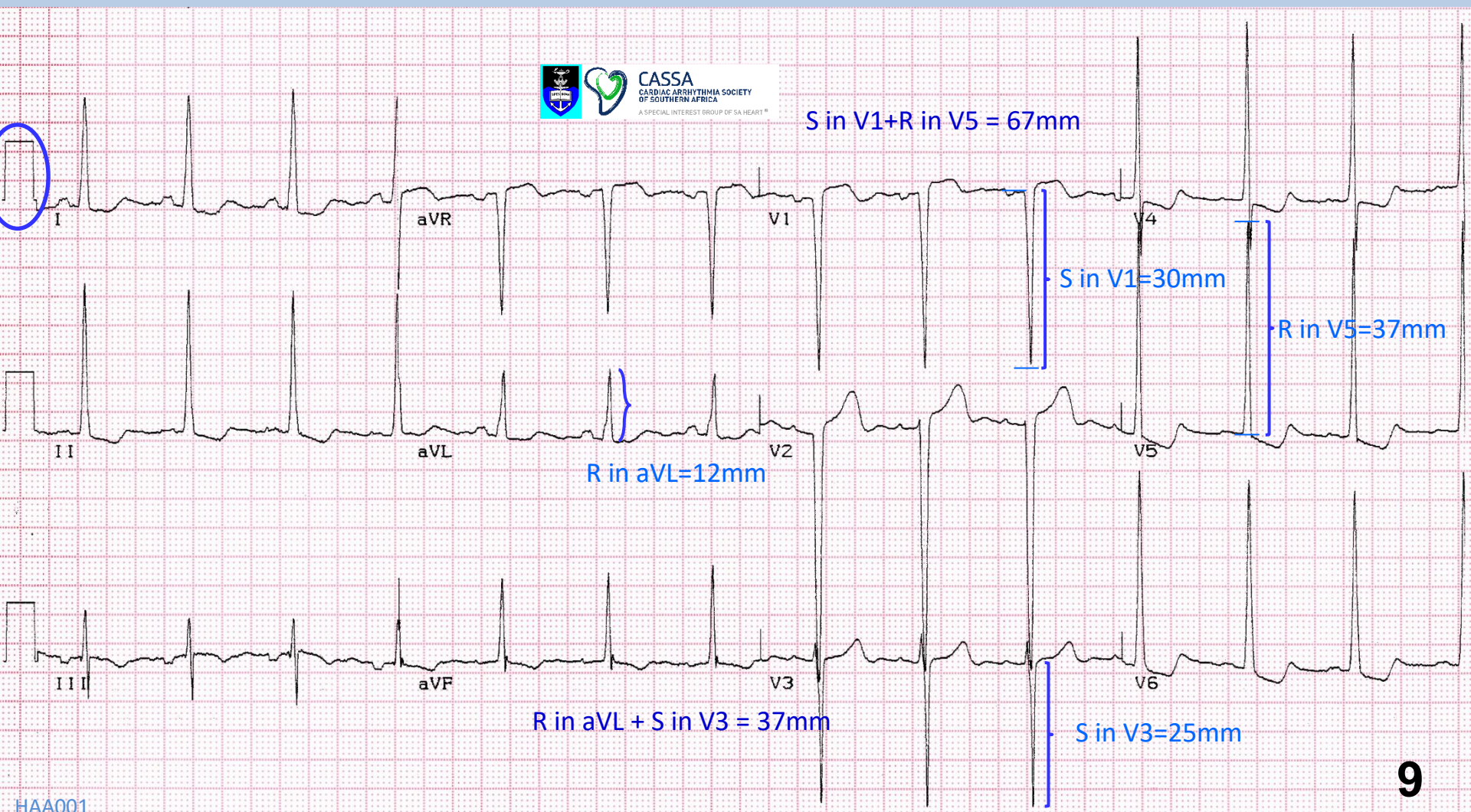
P negative > ,04mV
I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
PR 160ms
P wave 120ms
bifid
Rate 78/bpm (13x6)
Regular
QRS 80ms


CASSA
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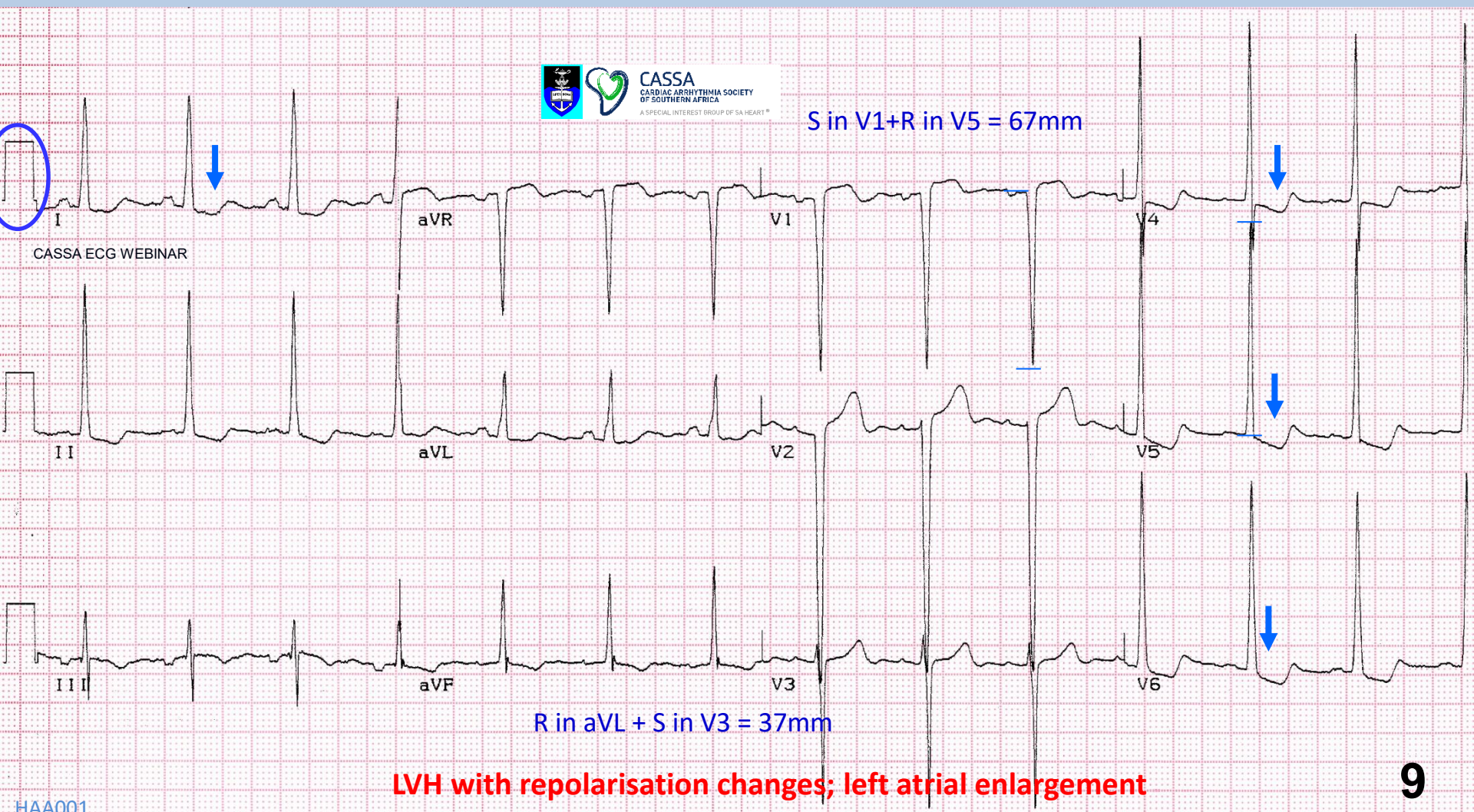
S in V1+R in V5 = 67mm
S in V1=30mm
R in V5=37mm
R in aVL=12mm
R in aVL + S in V3 = 37mm
S in V3=25mm
I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6

HAA001

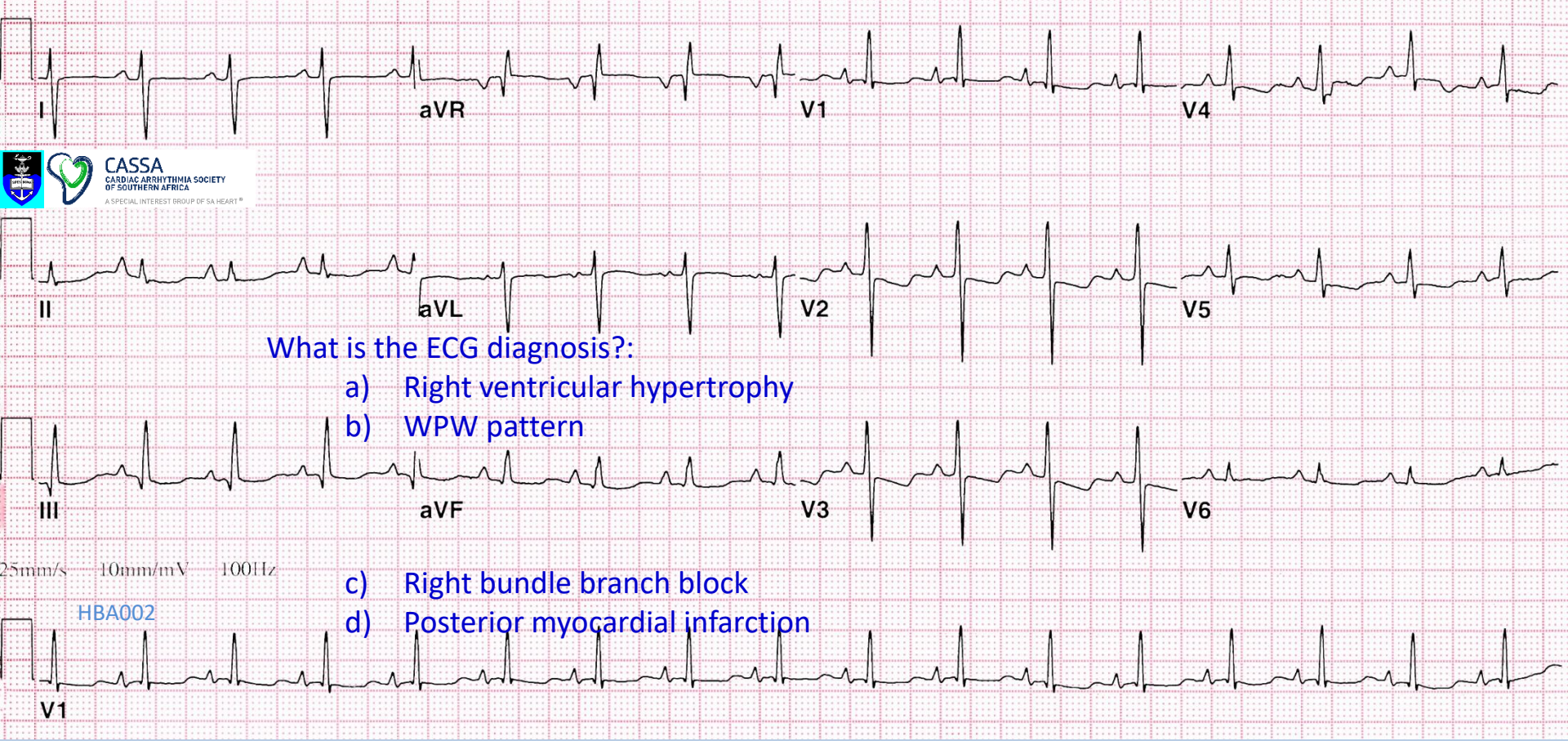
ECG Criteria for Left Ventricular Hypertrophy
Aged 40 years and older

- Sokolow-Lyon:
  - S in V1 + R in V5 (V6) > 3,5mV (35mm)
  - R in aVL > 1,1mV (11mm)
- Cornell:
  - S in V3 + R in aVL > 28 mm (men)
  - S in V3 + R in aVL > 20 mm (women)



LVH with repolarisation changes; left atrial enlargement

HAA001



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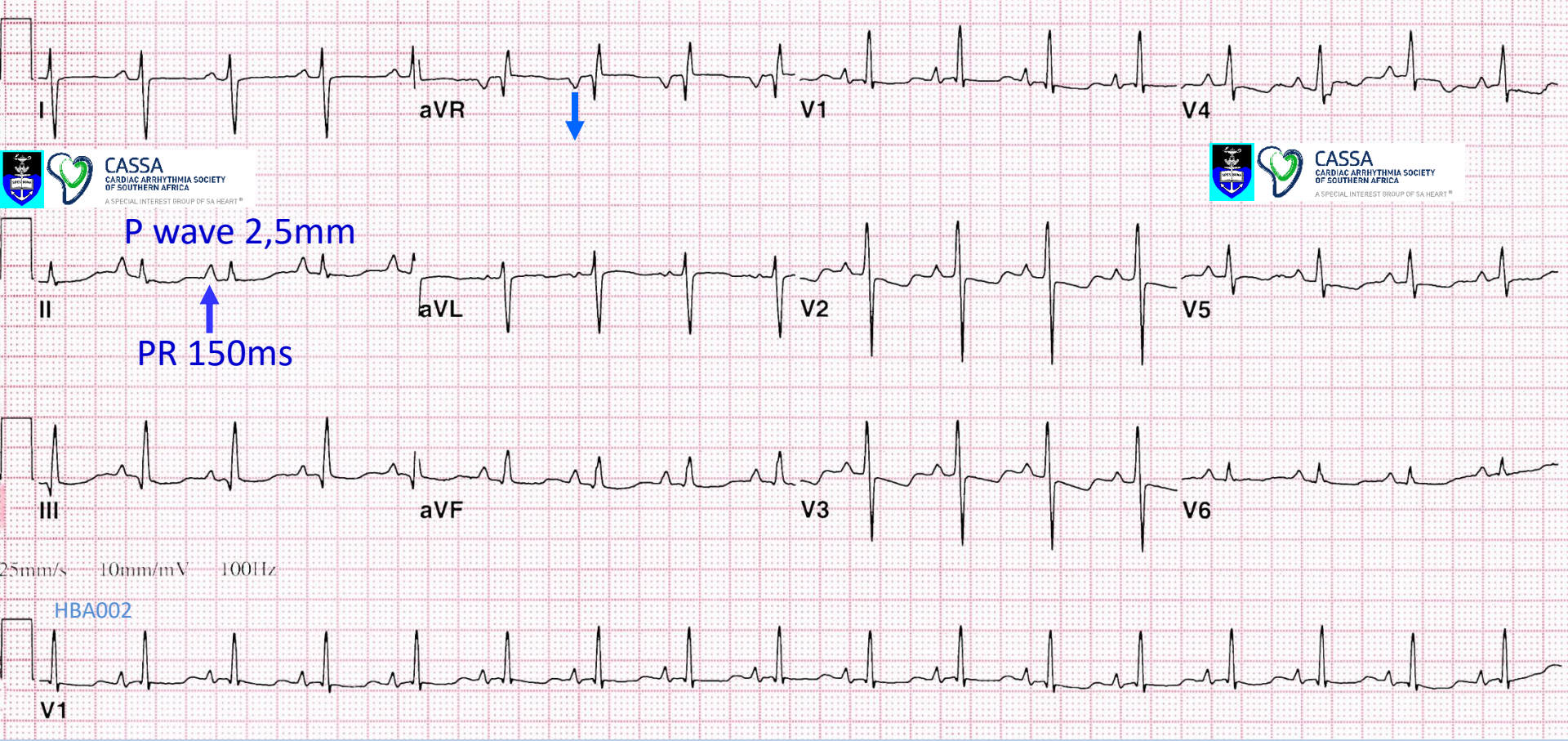
What is the ECG diagnosis?:

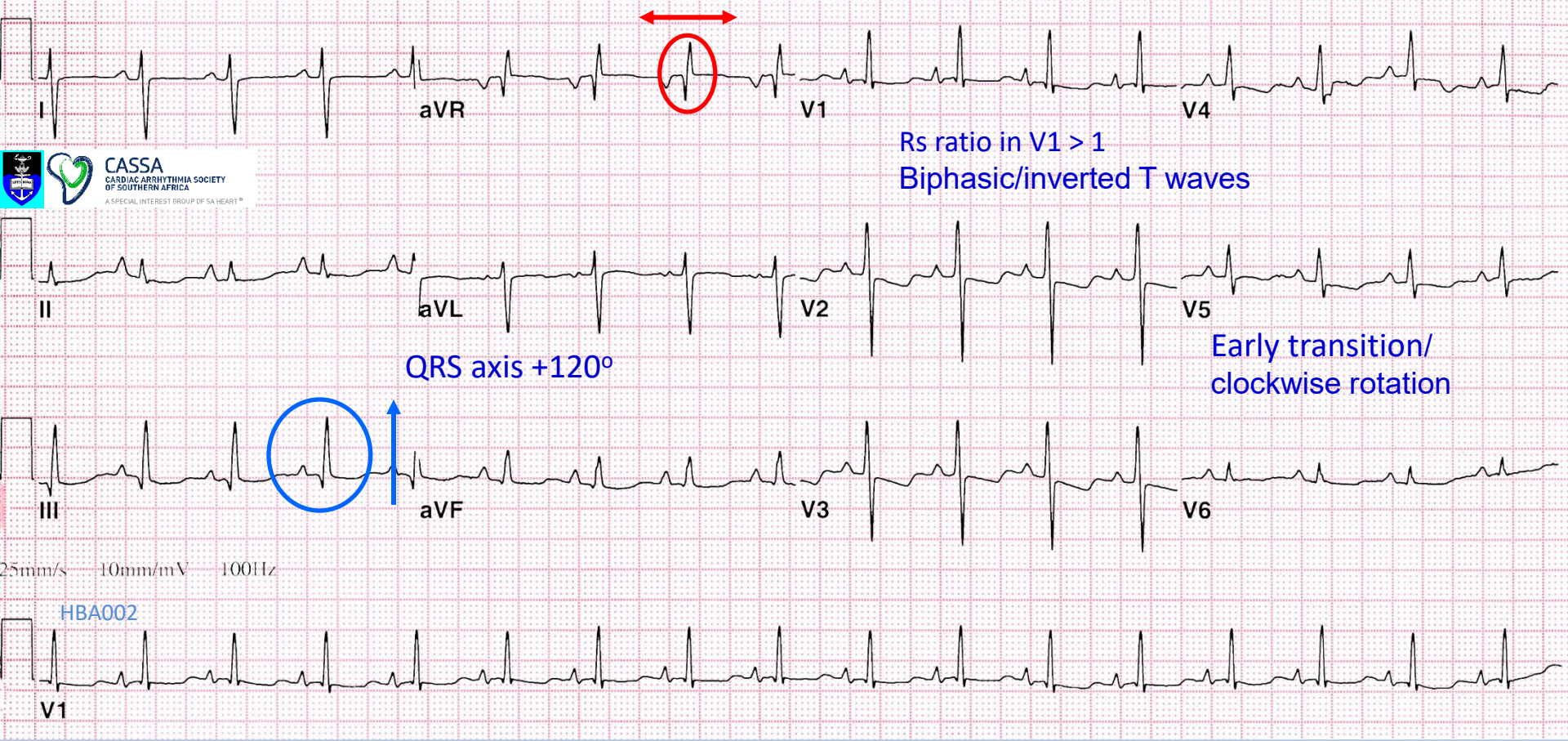
a) Right ventricular hypertrophy
b) WPW pattern
c) Right bundle branch block
d) Posterior myocardial infarction



Rate 102/bpm (17x6)

Regular

QRS 80ms



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Rs ratio in V1 > 1

Biphasic/inverted T waves

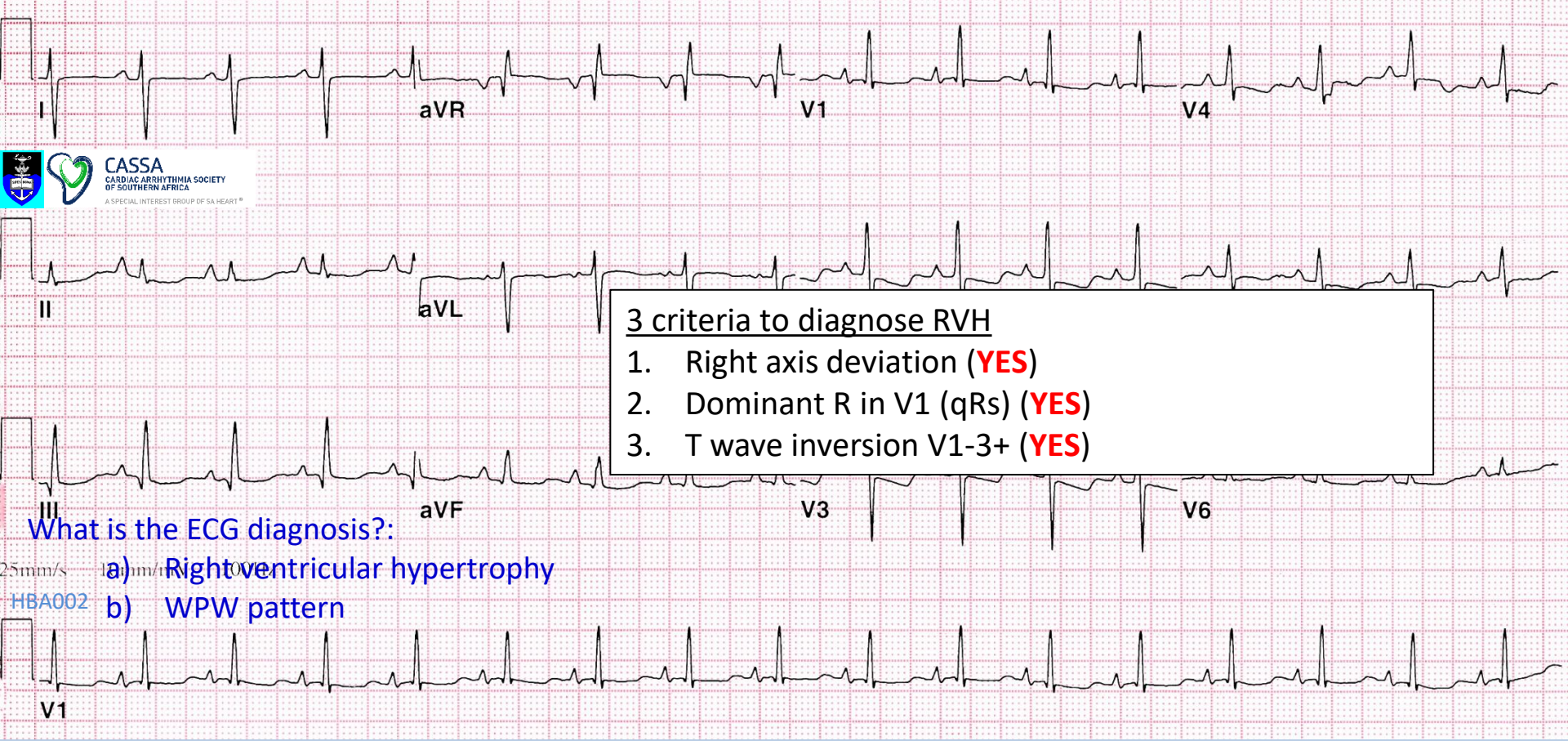
QRS axis +120º

Early transition/ clockwise rotation

Rate 102/bpm (17x6)

Regular

QRS 80ms



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3 criteria to diagnose RVH

1. Right axis deviation (**YES**)
2. Dominant R in V1 (qRs) (**YES**)
3. T wave inversion V1-3+ (**YES**)

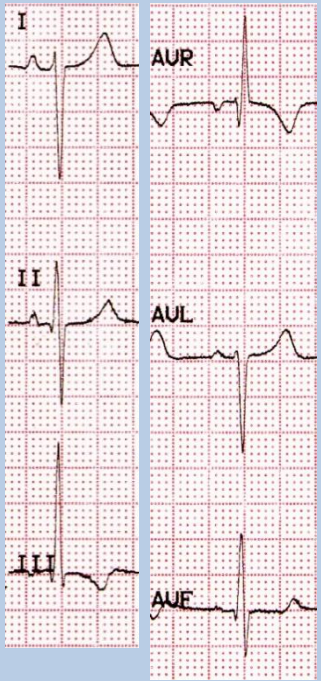
What is the ECG diagnosis?:

a) Right ventricular hypertrophy
b) WPW pattern
c) Right bundle branch block
d) Posterior myocardial infarction

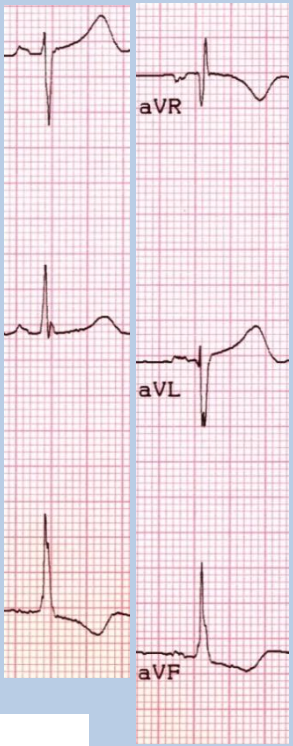
Severe right ventricular hypertrophy

Mechanisms of right axis deviation

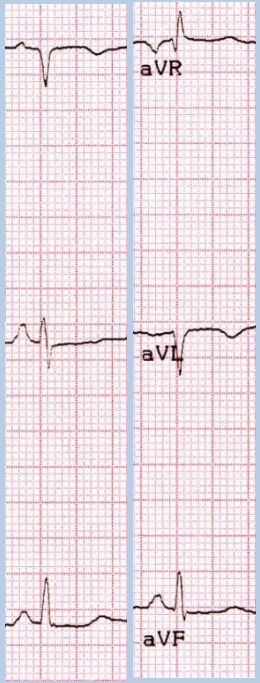
RVH



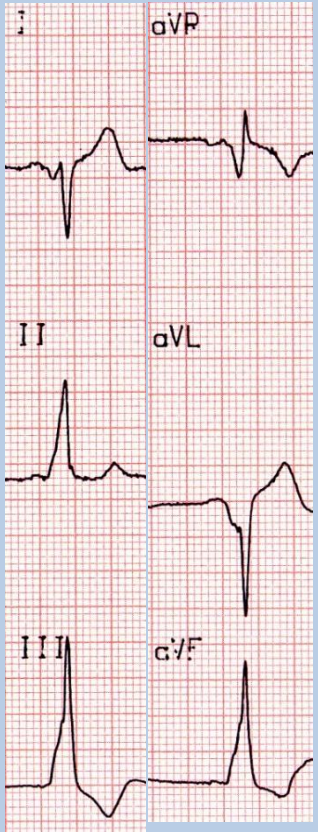
L posterior fascicular block



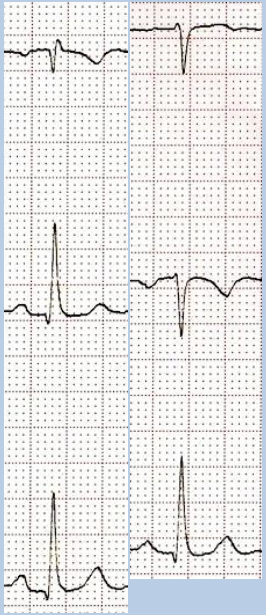
Lateral myocardial infarction



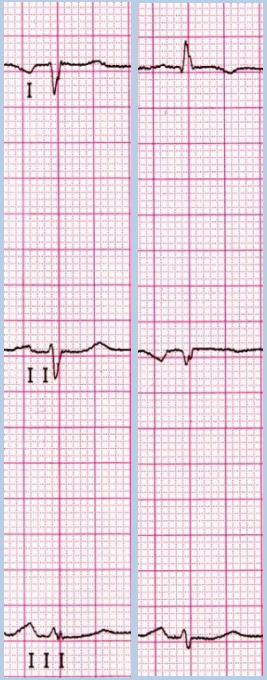
WPW pattern



Limb leads misplaced



Mirror-image dextrocardia



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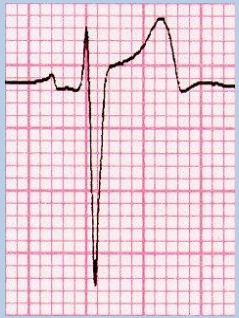
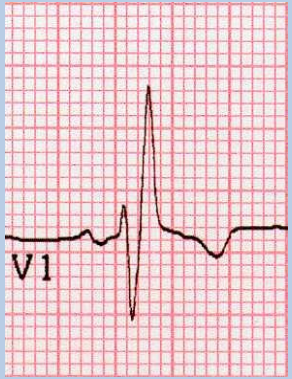
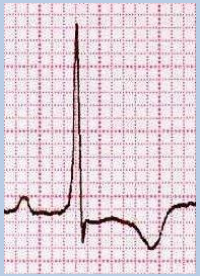
Dominant R wave in V1



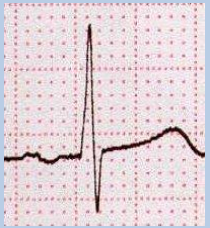
Normal



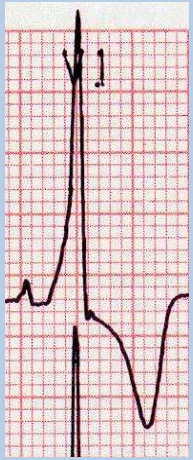
RBBB



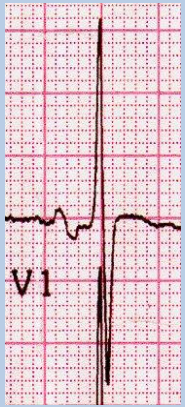
RVH



Posterior MI



WPW



Duchenne's

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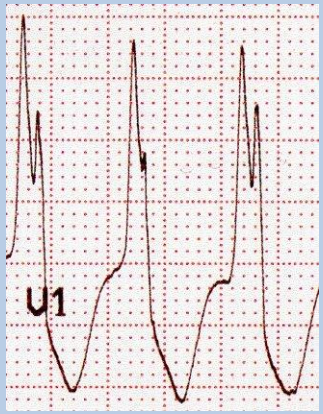
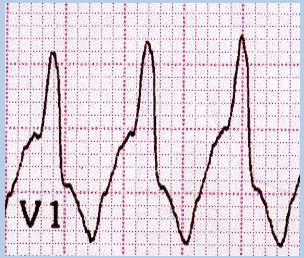
Anterior MI - RBBB

ARVC



Ventricular rhythms



Antidromic tachycardia - WPW

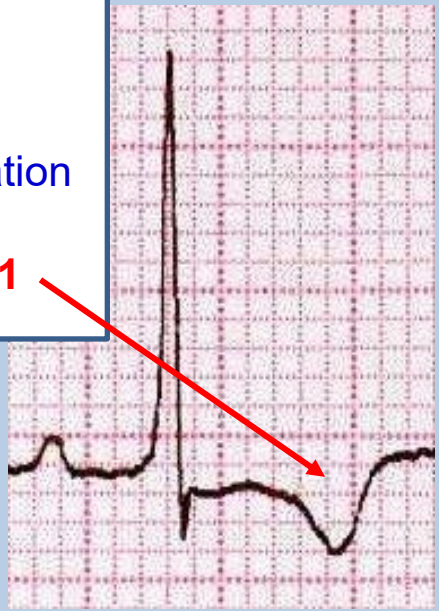
LV pacing

RVH vs posterior MI

RVH:

- Clinical
  - Depends on cause
  - Signs of RVH
- Echocardiography

- ECG
  - Right axis deviation
  - R>S in V1
  - **Inverted T in V1**

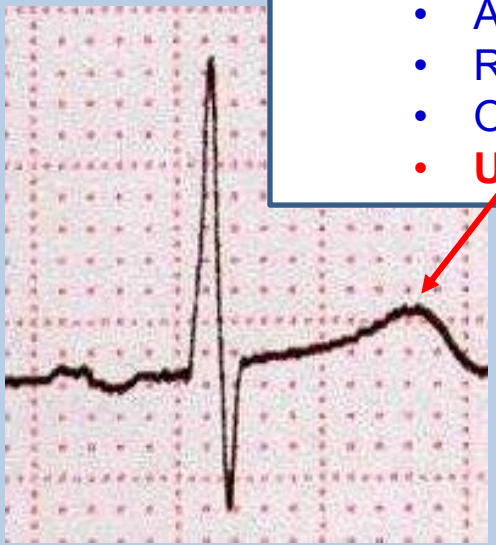


RVH

Posterior MI:

- Clinical
  - History of chest pain
  - No signs of RVH

- ECG
  - Axis variable
  - R>S in V1
  - Often inferior MI
  - **Upright T in V1**



Posterior MI

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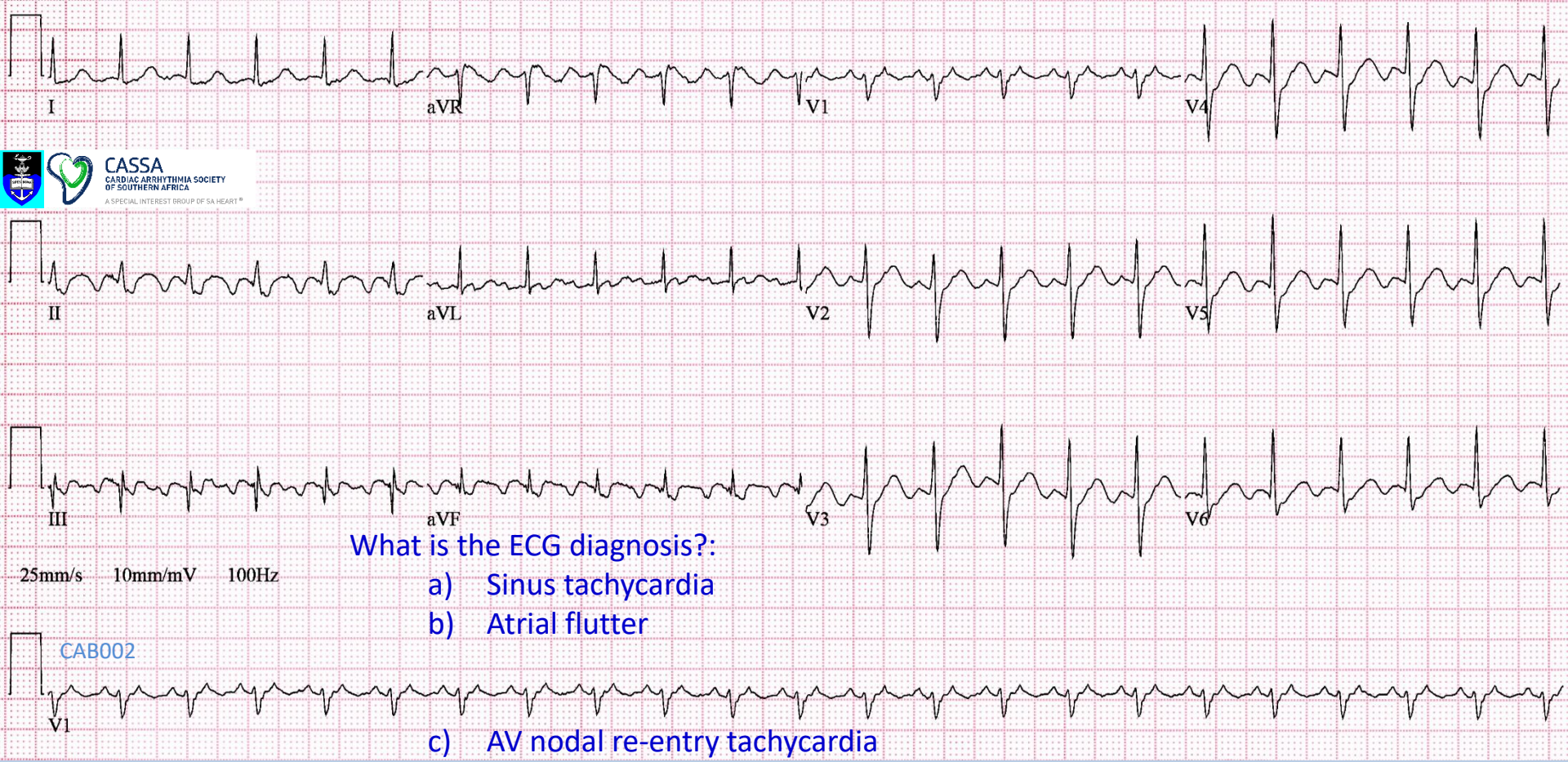

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What is the ECG diagnosis?:

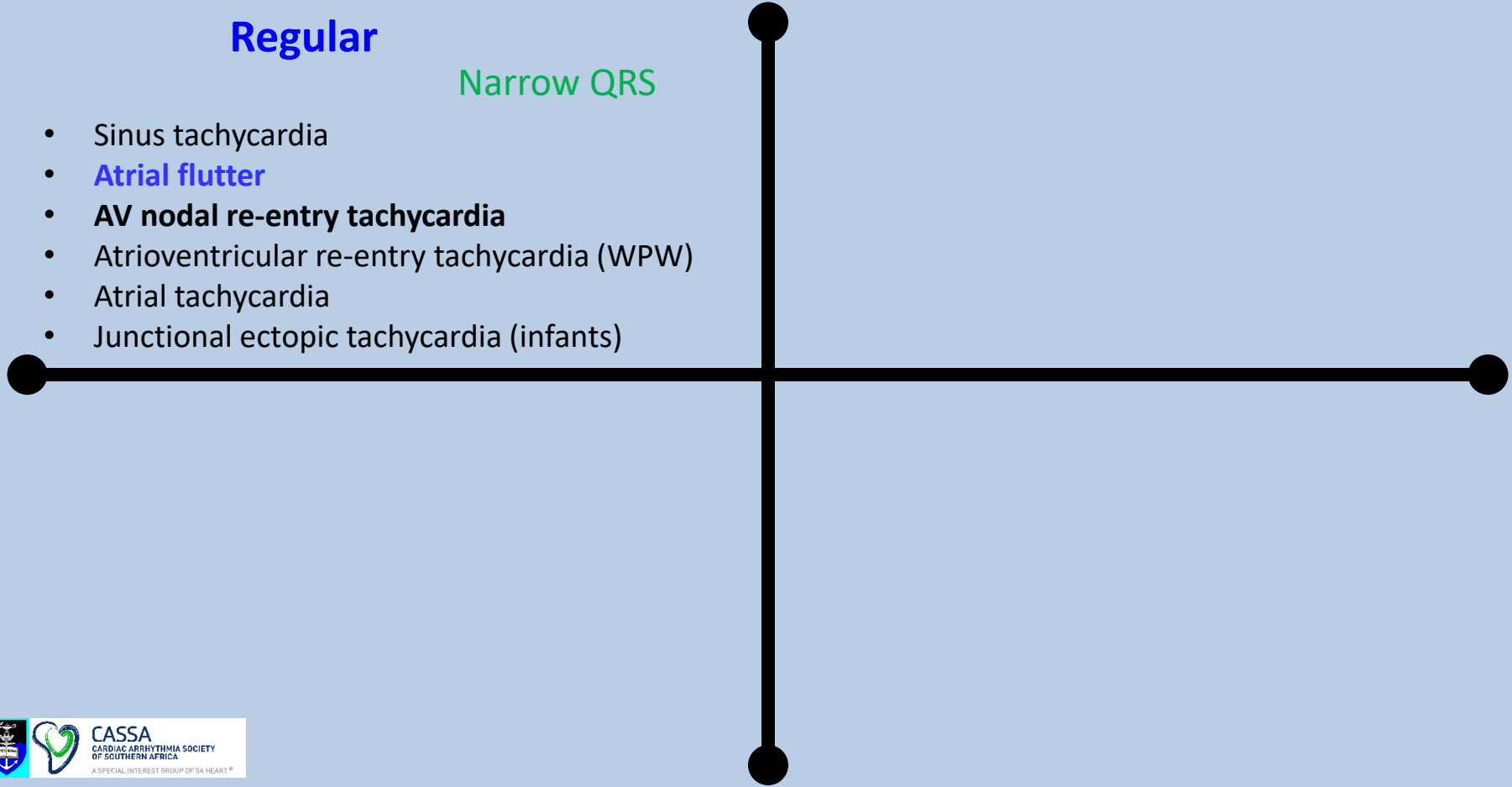
a) Sinus tachycardia
b) Atrial flutter
c) AV nodal re-entry tachycardia
d) AV re-entry tachycardia

TACHYARRHYTHMIAS

Regular

Narrow QRS

- Sinus tachycardia
- **Atrial flutter**
- **AV nodal re-entry tachycardia**
- Atrioventricular re-entry tachycardia (WPW)
- Atrial tachycardia
- Junctional ectopic tachycardia (infants)



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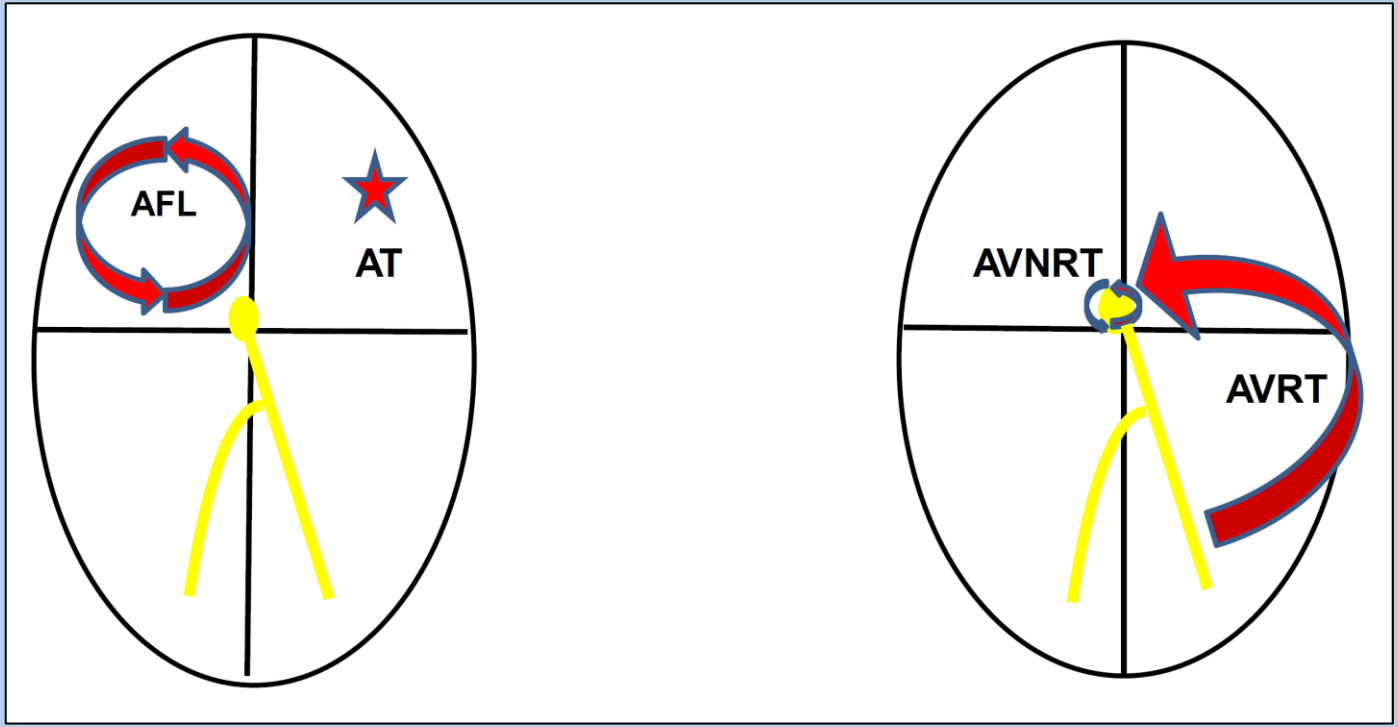
Narrow, complex regular tachycardias



KEY: Identify P waves or flutter waves

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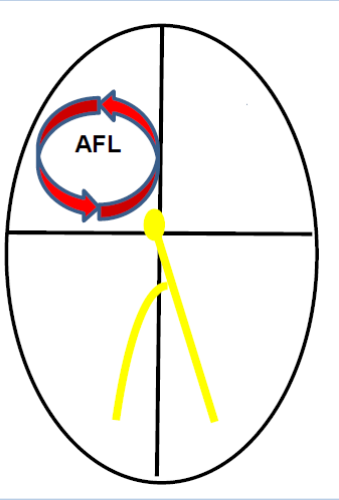
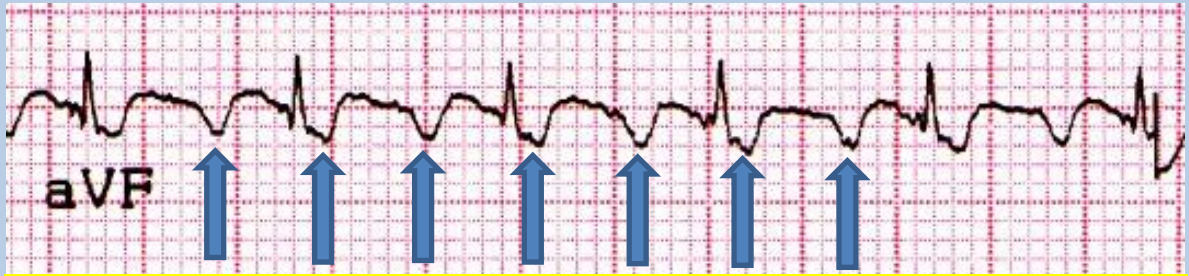
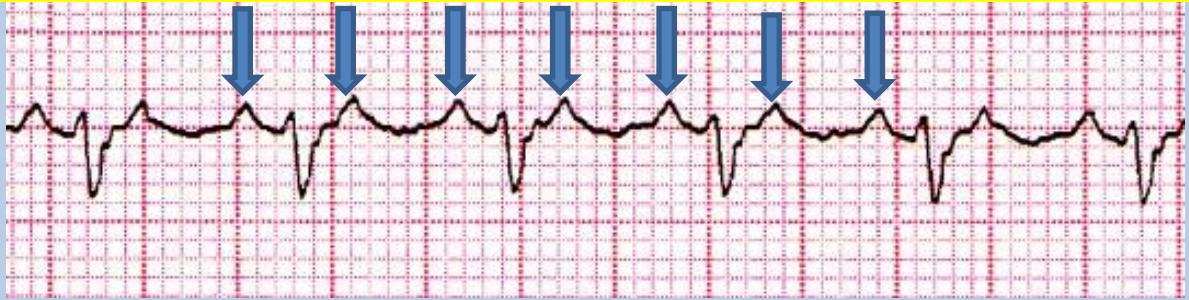




Flutter waves in the inferior leads shows an initial gradual, followed by a deeply negative component and then a terminal positive deflection

Flutters waves usually 240-360bpm with 2:1 AV block

Lead V1 has an initial inverted component followed by an upright component



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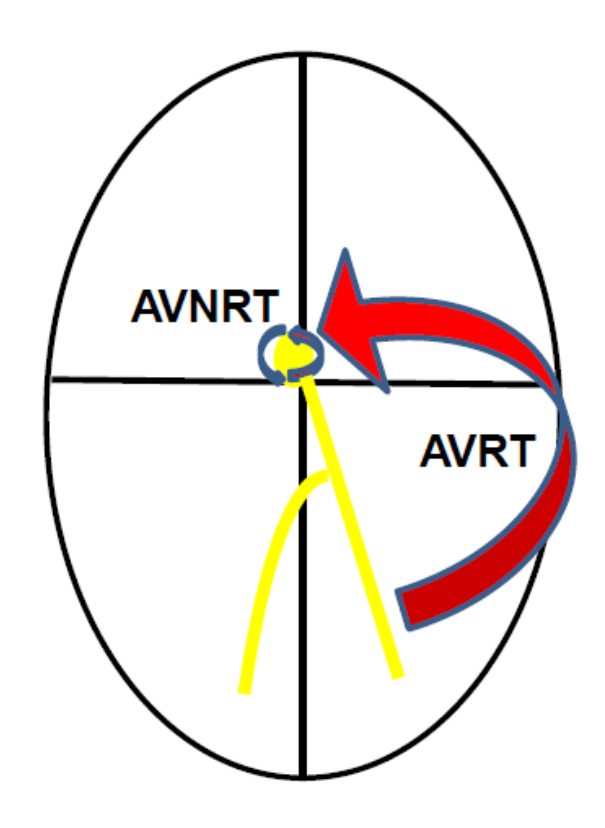
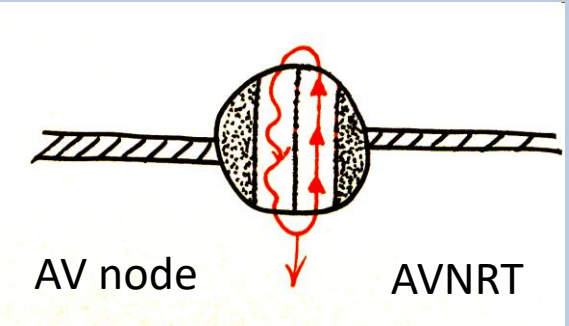
What is the ECG diagnosis?:

a) Sinus tachycardia
b) Atrial flutter

c) AV nodal re-entry tachycardia
d) AV re-entry tachycardia





Typical AVNRT usually causes a very short RP tachycardia i.e. the QRS complex is followed immediately by a retrograde P wave

Typical AVRT usually causes a short RP tachycardia i.e. the QRS complex is followed by a P wave that is >90ms from the QRS complex.

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TYPICAL AVNRT

Pseudo R waves
RP interval = 60ms

No P waves visible; possible pseudo-S waves in AVF (retrograde P)

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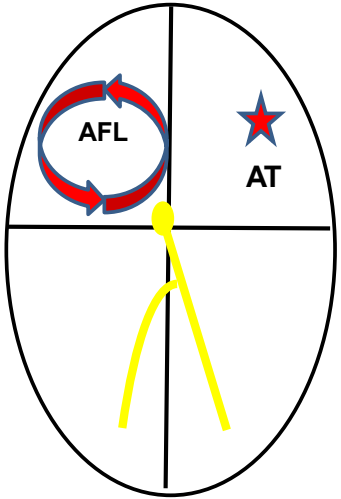
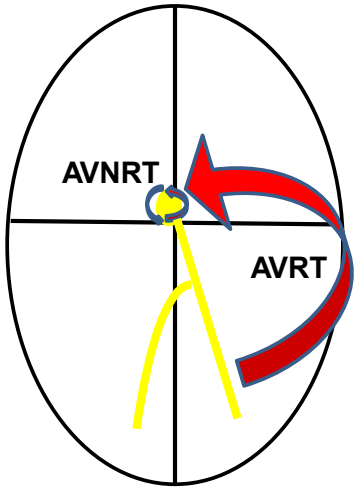
NEJM 2012;367;1438

Carotid sinus massage/Valsalva manouevre





Atrial flutter or atrial tachycardia are AV nodal independent tachycardias. Carotid massage causes transient AV block which reveals underlying P waves

AVJRT (AVNRT/AVRT) are AV nodal dependent tachycardias. Carotid massage CSM may terminate the tachycardia

Useful for terminating the arrhythmia, but also to determine the cause (Valsalva slightly better than CSM) – 20-25% success rate

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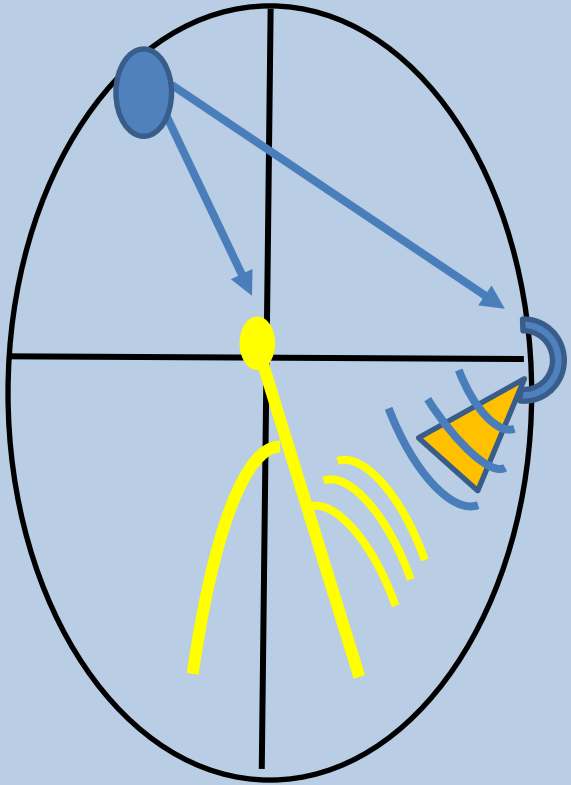
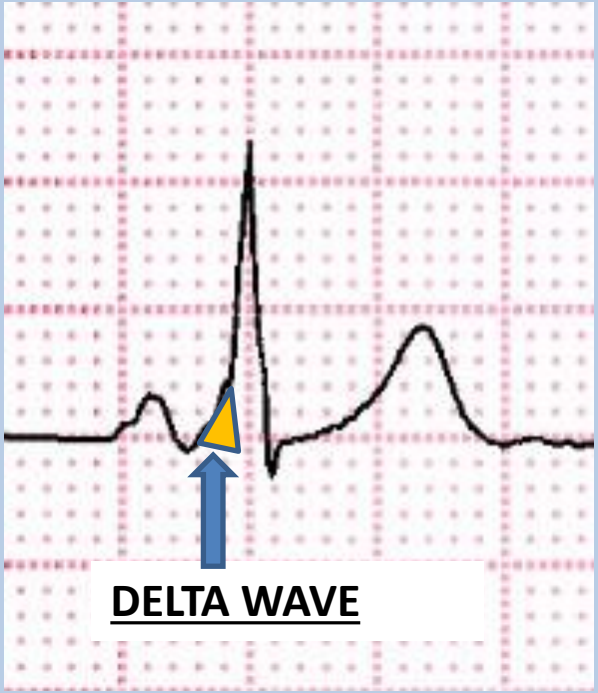
WPW





The Delta wave is caused by ventricular pre-excitation, because of rapid conduction over accessory pathway

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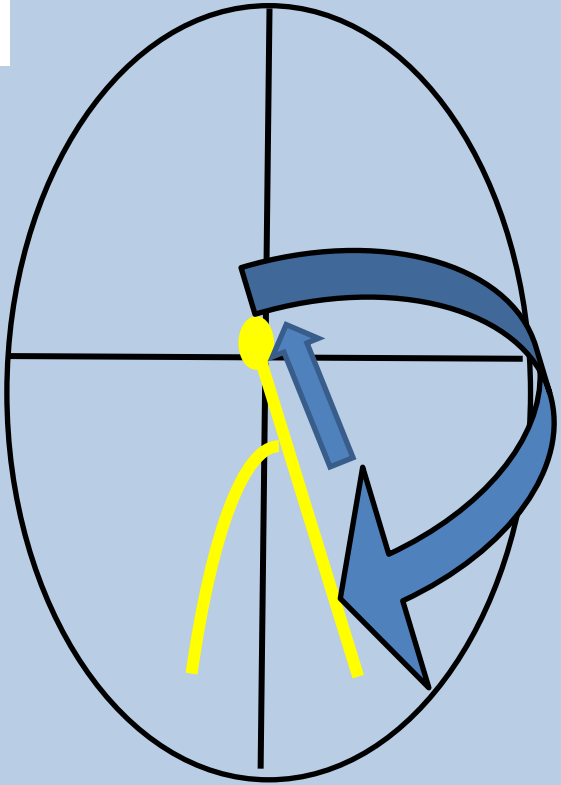
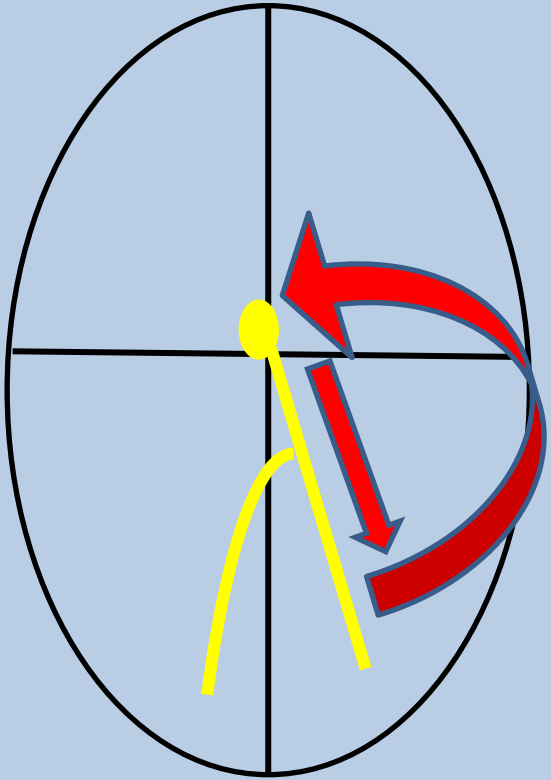


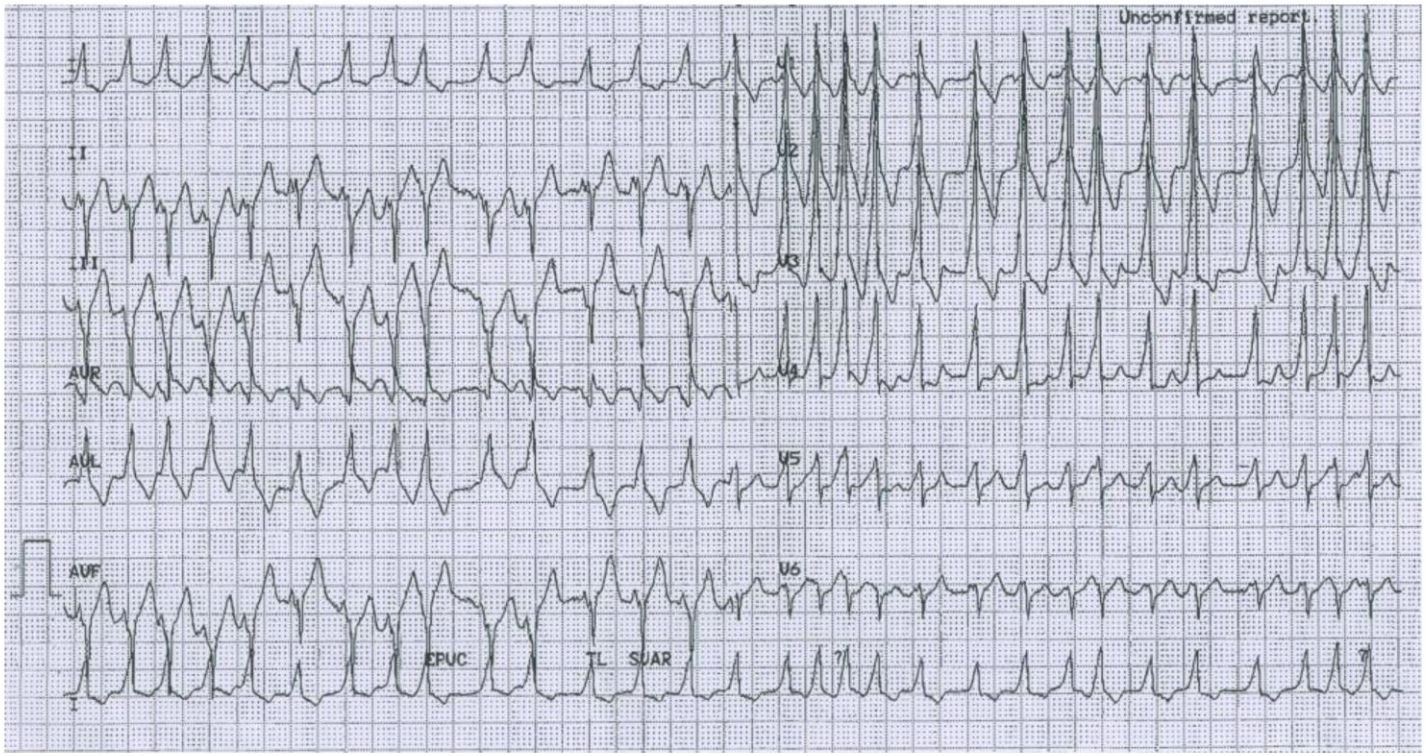


Antidromic AVRT (uncommon)

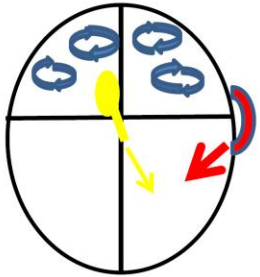
WIDE COMPLEX TACHYCARDIA

Orthodromic AVRT (common)

NARROW COMPLEX TACHYCARDIA (USUALLY)



An example of a wide complex, irregular tachycardia. This is pre-excited atrial fibrillation over a left lateral accessory pathway. Note that the QRS complexes are wide and vary in morphology because of variable degrees of fusion over the accessory pathway and the AV node.



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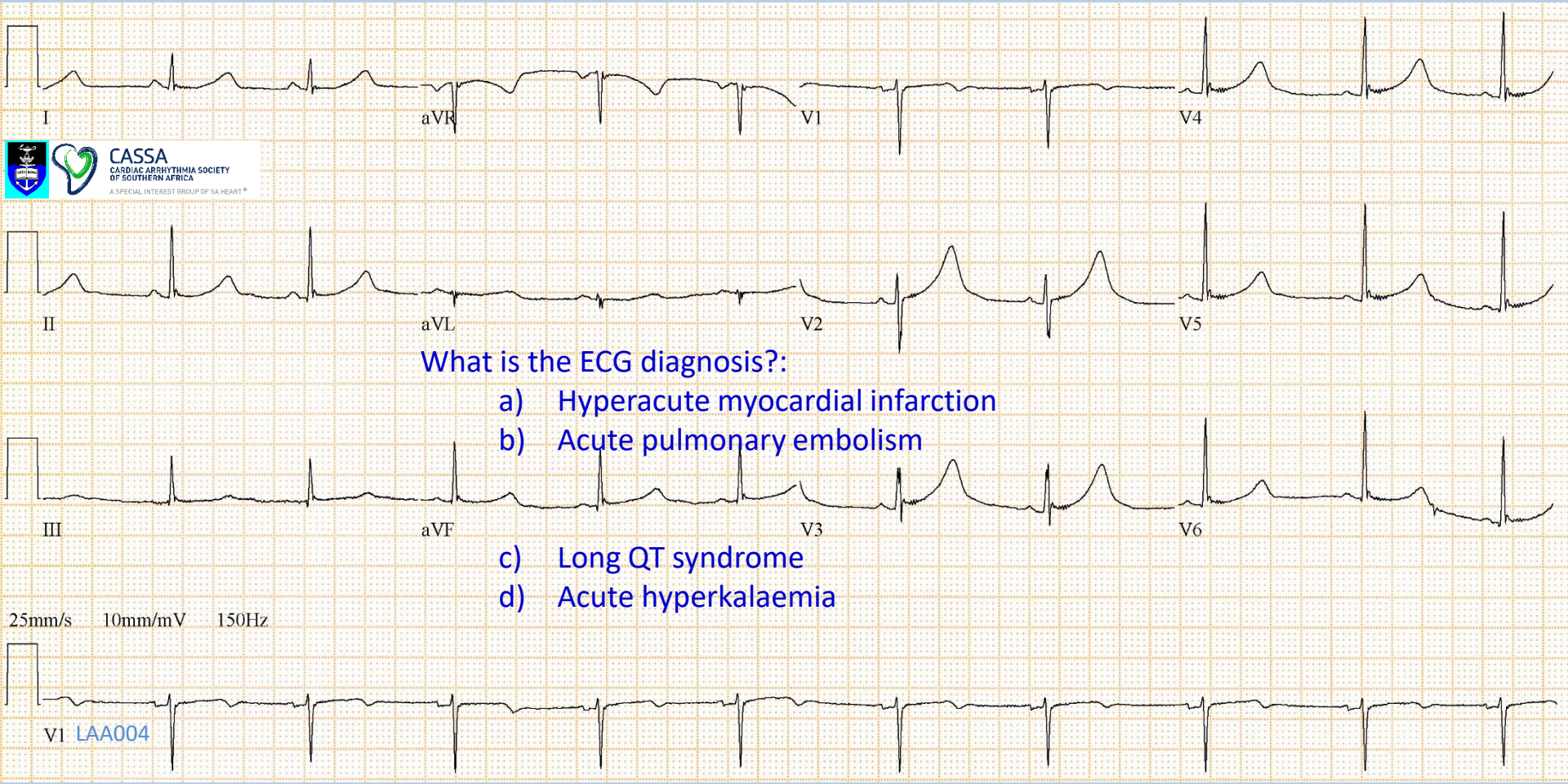

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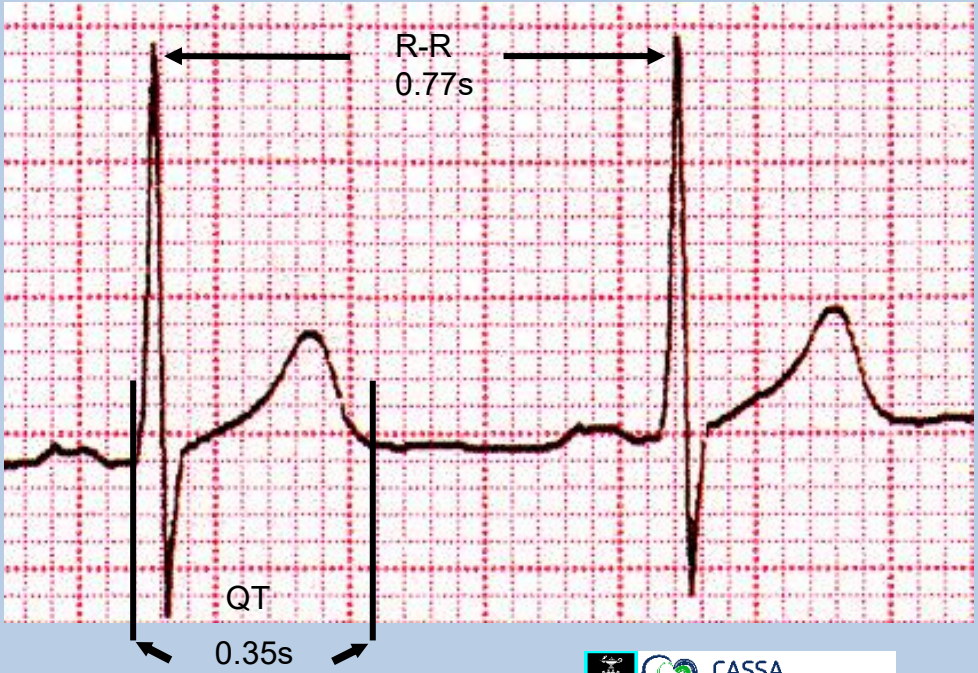
What is the ECG diagnosis?:

a) Hyperacute myocardial infarction
b) Acute pulmonary embolism
c) Long QT syndrome
d) Acute hyperkalaemia

QT interval

Q-T: measure from beginning of the QRS to the end of T wave

Measure the longest QT – usually V2 – V4



Correct using Bazett's formula - measurements in seconds

$$QTc = \frac{Q\text{-}T}{\sqrt{R\text{-}R}}$$

$$\frac{0.35s}{\sqrt{0.77s}} = 0.39s$$

Normal QTc:
≤ 0.44s (440ms) – males
≤ 0.46s (460ms) - females

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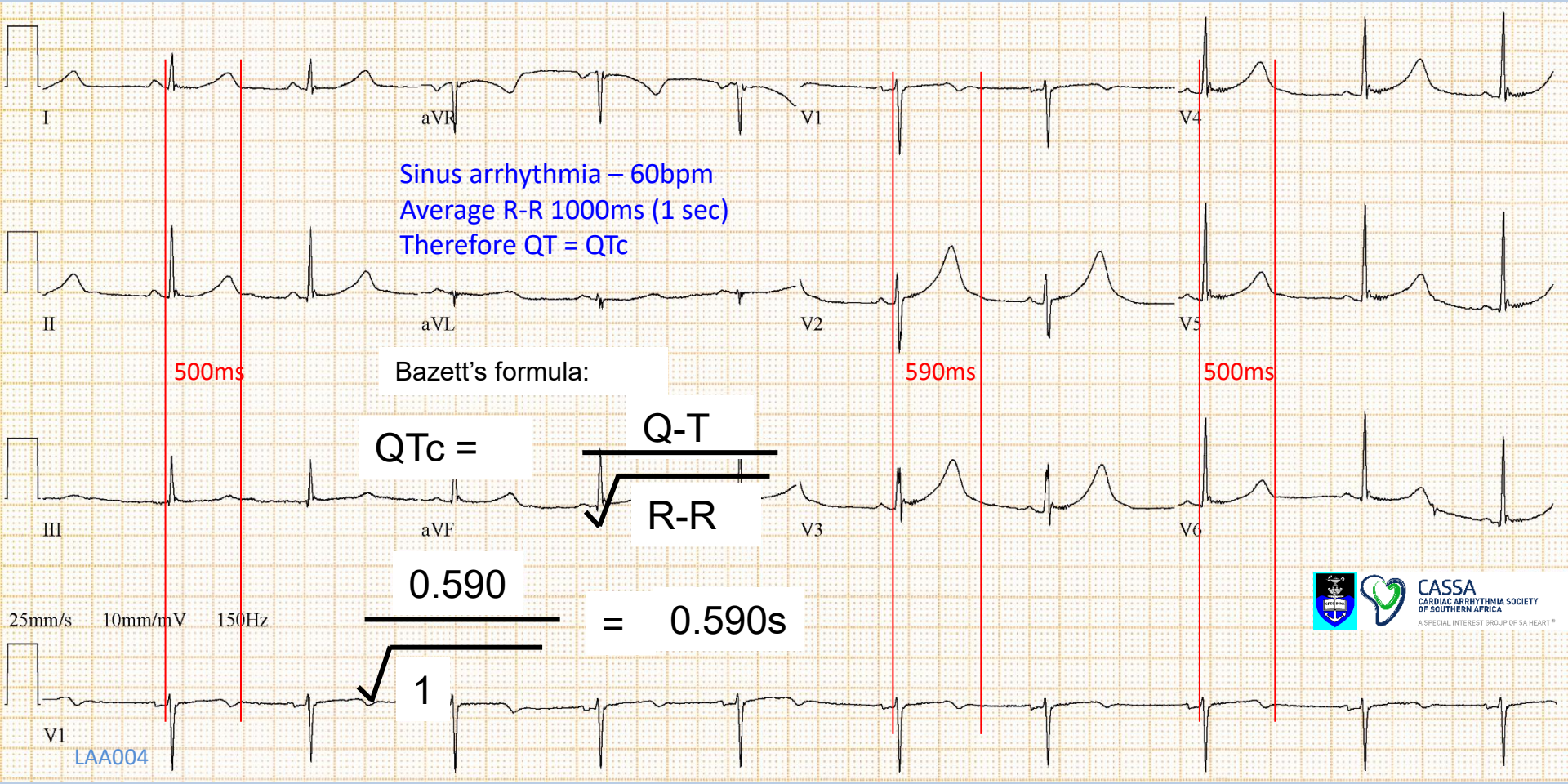
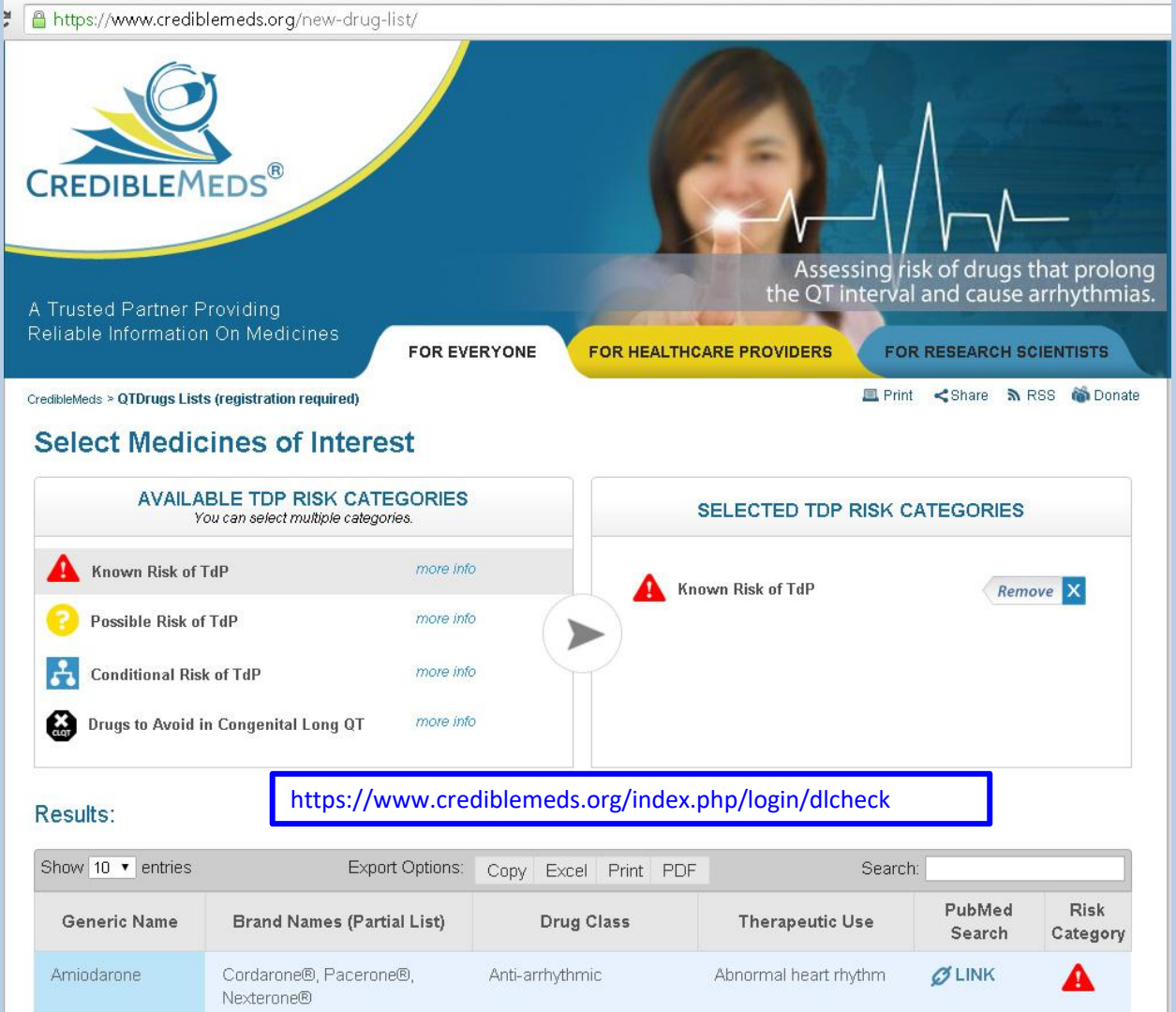


ECG of a 22 year old woman with LQTS type I



There are more than 160 drugs now known to prolong QT.

At last count, 59 definitely cause TdP.

259 should be avoided in LQTS

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