

Webinar – 12th November 2025, Module 1



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**CARDIAC ARRHYTHMIA SOCIETY
OF SOUTHERN AFRICA**

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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



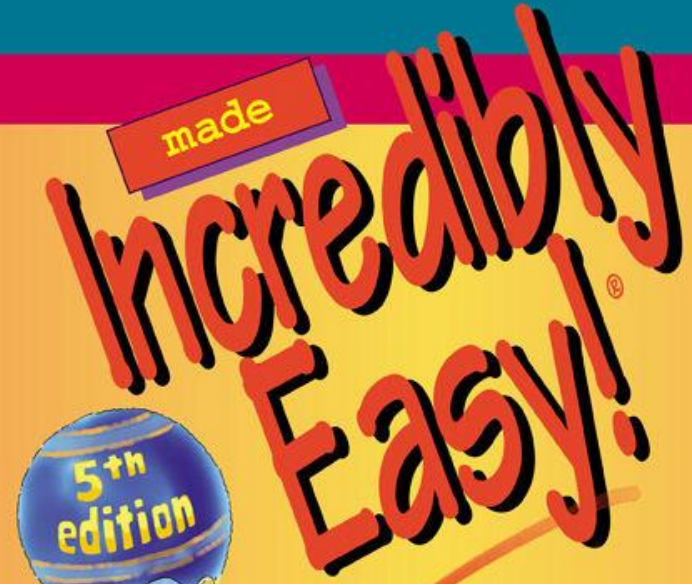
EIGHTH EDITION

The ECG

Made Easy

John R. Hampton

ECG Interpretation



ECGs are not easy – they require knowledge, a systematic approach and practice. This course will guide your approach to ECG analysis and concentrate on those ECGs that really matter.



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What can you learn from an ECG?

- Rhythm
 - Conduction
 - Structural heart disease
 - Myocardial infarction
 - Hypertrophy
 - Atria
 - Ventricles
 - Pericarditis
 - Transient abnormalities
 - Ischaemia
 - Electrolytes
- Drug effects
 - QT prolongation
 - Primary ECG syndromes
 - Wolff-Parkinson-White (WPW)
 - Congenital long QT syndrome (LQTS)
 - Brugada syndrome

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

What are “Essential ECGs”?

- **It indicates a lethal condition**
 - A missed diagnosis may be fatal
 - Appropriate treatment will save lives
 - The ECG is the only, or the principal, means of diagnosis
- **It adds important information to the clinical diagnosis**
 - Helps to make or confirm the diagnosis
 - Indicates an additional problem
 - Aids in prognosis
- **It indicates an important condition, not otherwise diagnosable**
- **It indicates an important condition, not otherwise suspected**
- **It may reassure one**

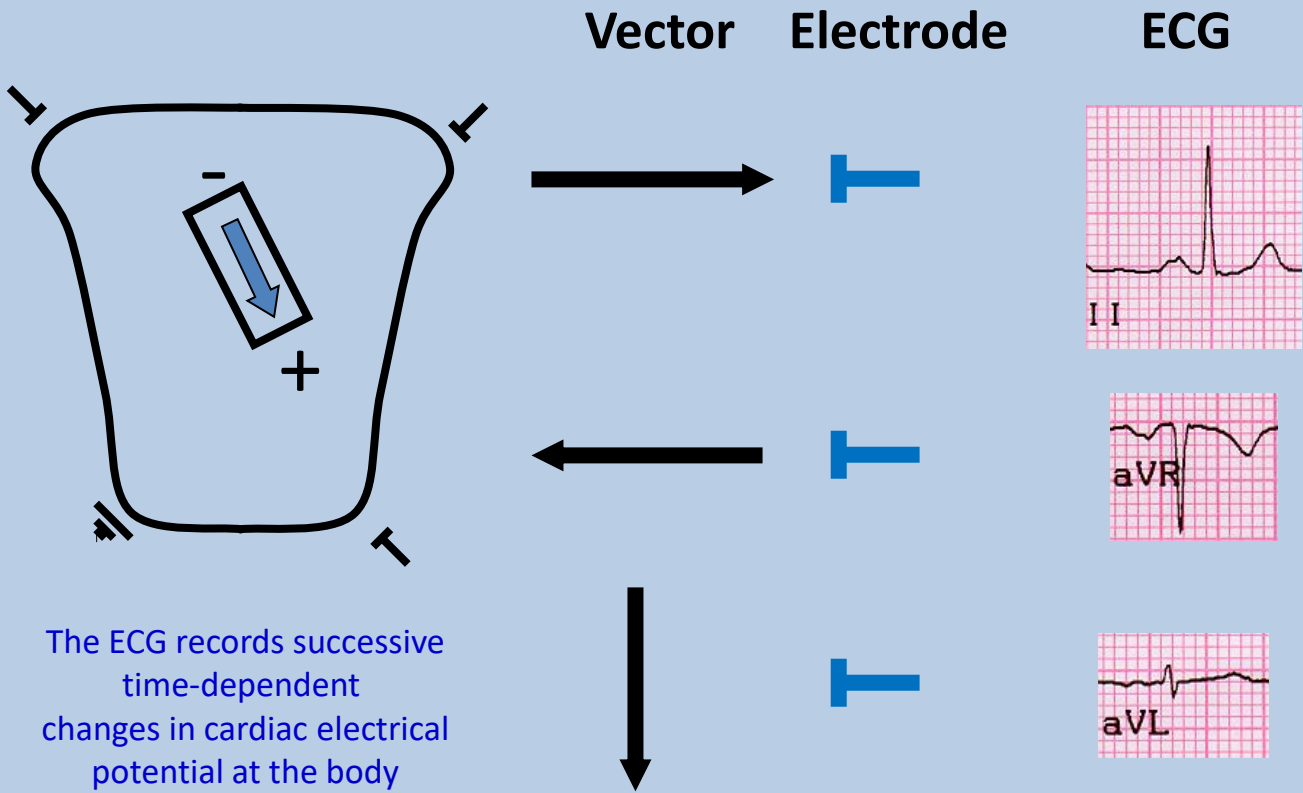


Some examples of “Essential ECGs”

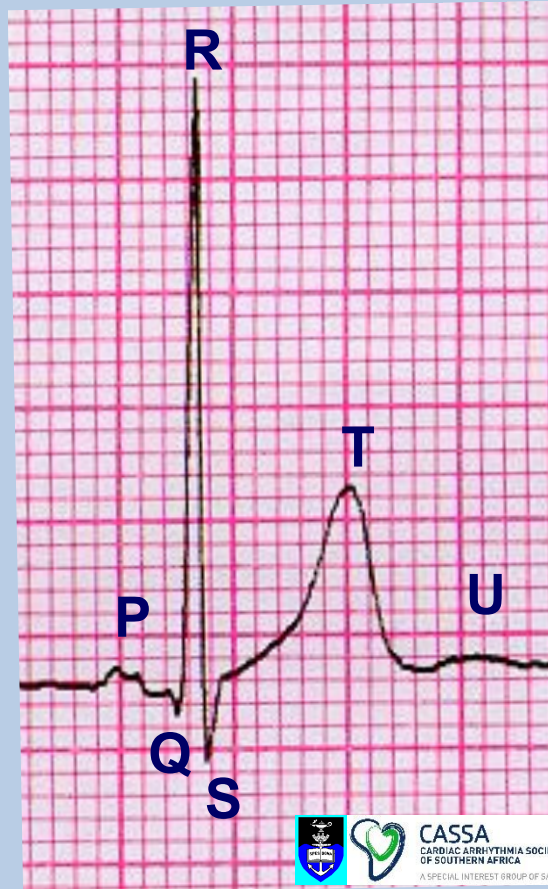
ECGs critical to the diagnosis

- **Lethal conditions**
 - Complete heart block
 - Acute ST elevation myocardial infarction (STEMI)
 - Ventricular tachycardia
- **Serious consequences if not diagnosed**
 - Atrial fibrillation (stroke)
 - Atrial flutter (stroke)
- **Potentially lethal conditions**
 - Healed (old) myocardial infarction
 - Congenital long QT syndrome
- **Essential for accurate diagnosis**
 - All arrhythmias
- **It indicates an important condition, not otherwise suspected**
 - Wolff-Parkinson-White (WPW) pattern
- **Useful for prognosis**
 - Left ventricular hypertrophy
 - Bundle branch block

ECG recording

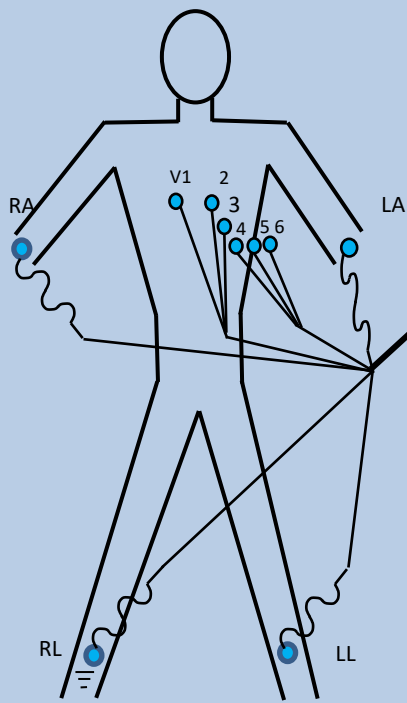


ECG waves

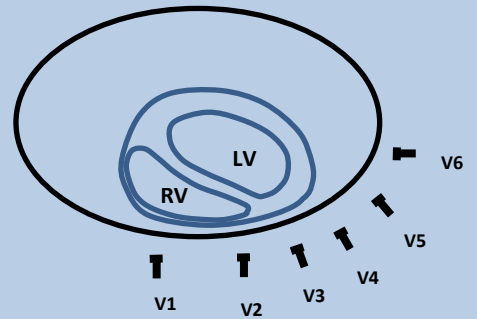
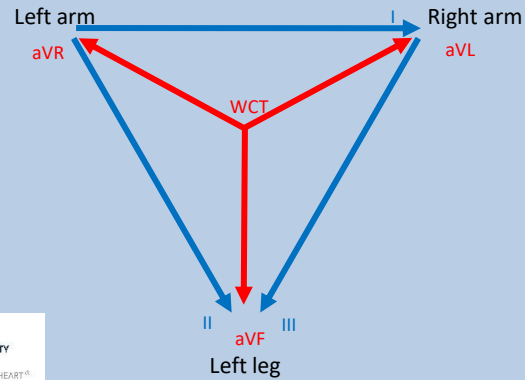
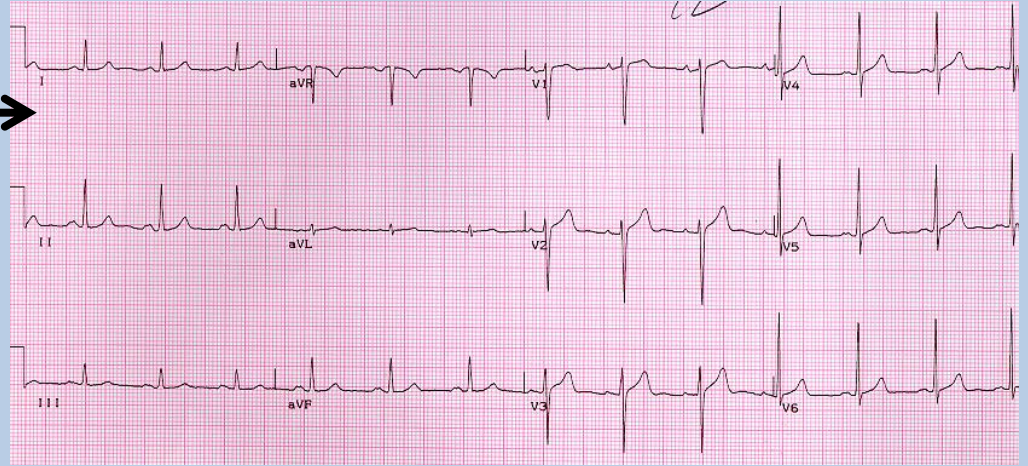


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ECG recording



ECG recorder



ECG recording

L

a



b



c



What is the correct placement of Chest lead electrodes?

ECG recording

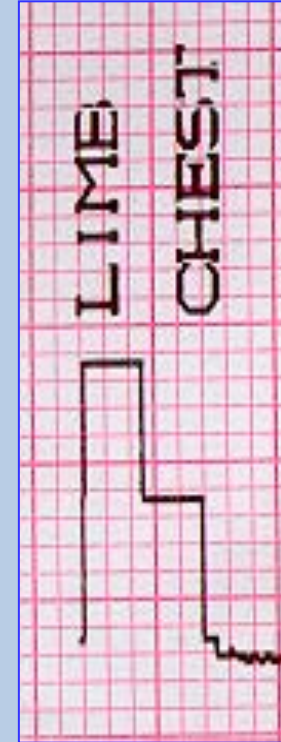
Chest 1/2 std
(1mv = 5mm)

25mm = 1 sec



0.04 sec = 40ms

0.2 sec = 200ms



Initial approach to an ECG – start with the patient

- **Clinical context e.g.:**
 - Level of consciousness, chest pain, shock, stable, no symptoms
- **First glance:**
 - Name, ID, date (without these the ECG is useless)
 - Start with the obvious:
 - Fast, slow or +/- normal rate
 - Any obvious abnormality: e.g. ST elevation
- **Detailed analysis**
 - Don't be distracted by any obvious abnormalities – avoid a “blink” diagnosis (exception: cardiac arrest)
 - Proceed to analyse systematically

Looking at the ECG

Primary observations

- **Ventricular rate:**
 - Normal (60 – 100/minute)
 - Slow (<60/minute)
 - Fast (>100/minute)
- **Regularity:**
 - Regular
 - Irregular
- **QRS width**
 - Normal ($\leq 100\text{ms}$)
 - Wide ($\geq 120\text{ms}$)
 - 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**

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

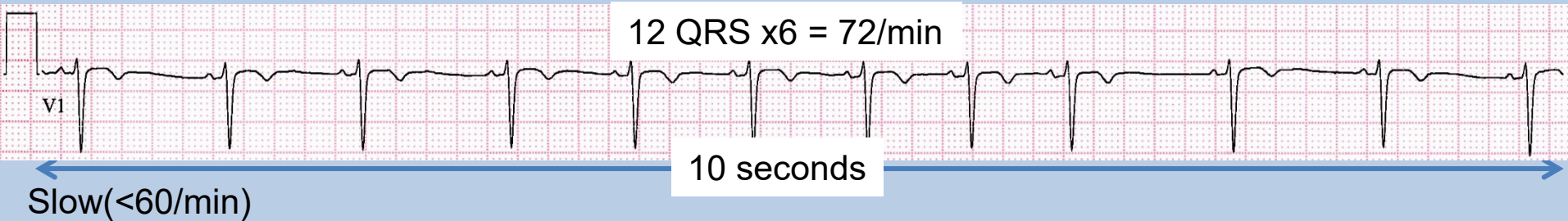
Beware snap (“blink”) diagnoses and hasty conclusions which lead to premature closure

Look beyond the obvious – analyse systematically

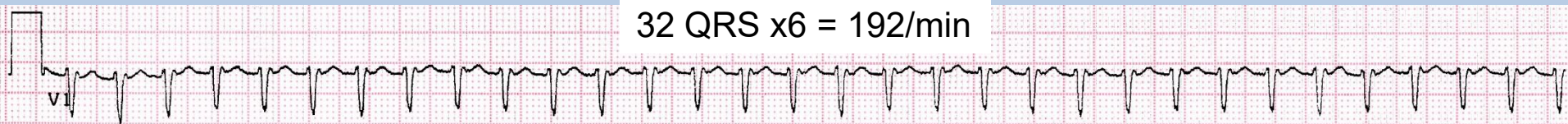
Ventricular rate

Rate = number of QRS complexes x6

Normal (60-100/min)



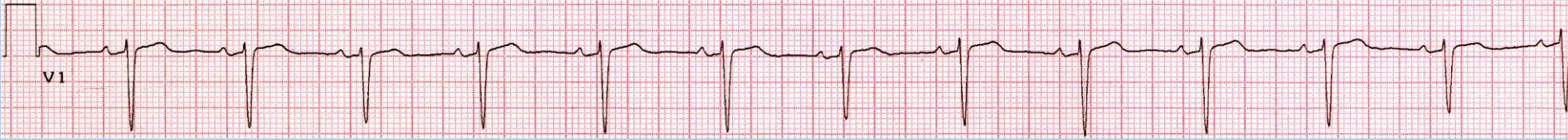
Fast (>100/min)



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Regularity

Regular – sinus rhythm (may be irregular, due to respiratory sinus arrhythmia)



Group beating – ventricular bigeminy

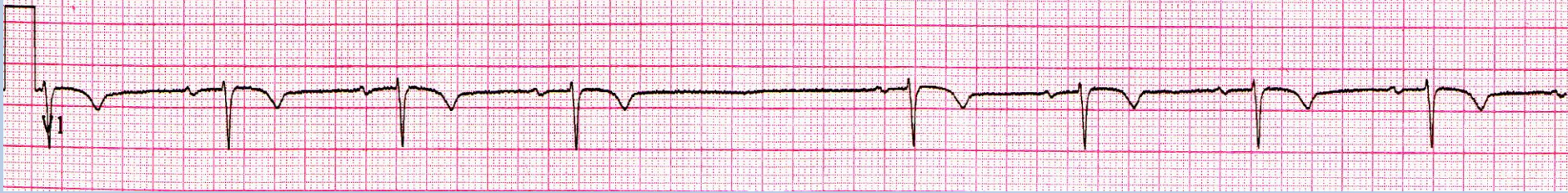


Group beating – 4:3 Wenckebach AV block



Regularity

Intermittent pauses during otherwise regular rhythm



Random irregularity – due to atrial fibrillation



QRS width (adults)

Normal ($\leq 100\text{ms}$)



Best measured
in the chest
leads

Wide ($\geq 120\text{ms}$)



QRS duration is difficult because the difference between the upper limit of normal (100ms) and wide (120ms) is only half a small block.

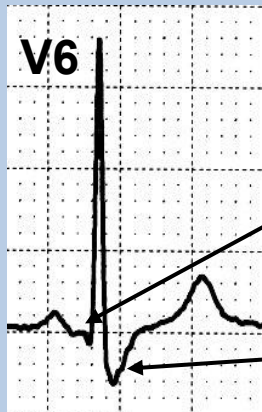


Typical patterns of right & left bundle branch block

RBBB



V1 & V2 positive
rSR' in V1



LBBB

V1 & V2 negative
V5 & V6 positive



Onset to nadir of S wave < 70ms



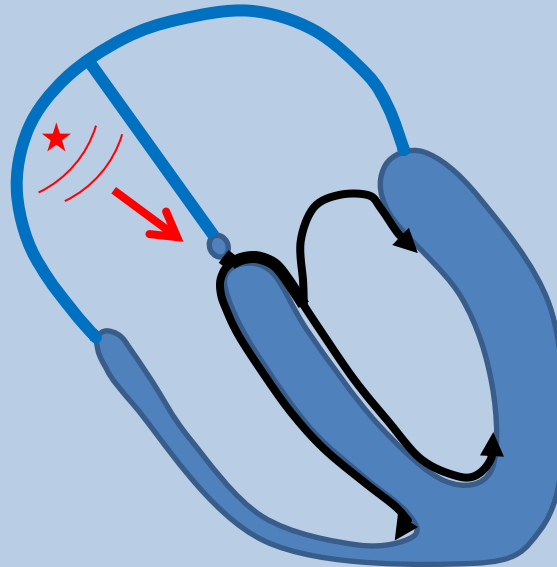
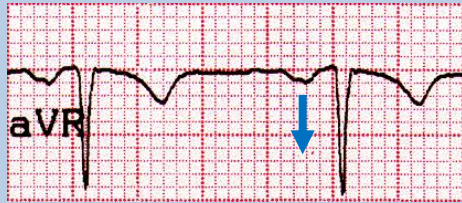
Slurred R wave

Absent septal q wave

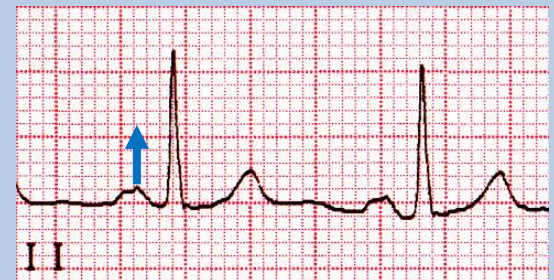
Inverted T wave



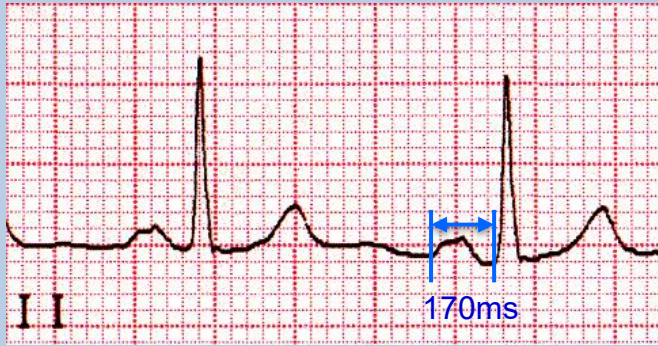
P waves



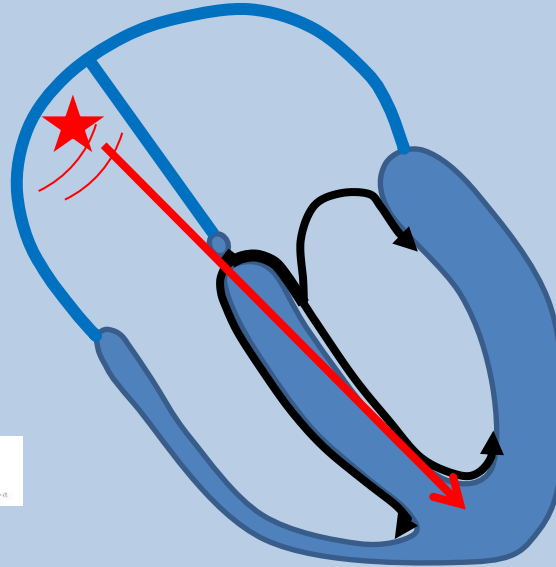
The sinus node encircles the entrance of the superior vena cava into the right atrium. Sinus P waves therefore are negative in aVR (moving away) and positive in Lead II (moving towards).



PR interval

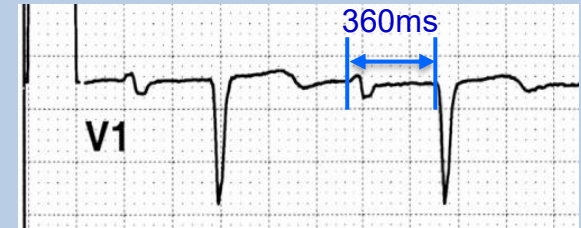


The time from the beginning of the P wave to the beginning of the QRS complex (normally 120-200ms)



The PR can be prolonged with slowing of conduction in the AV node and/or His Purkinje system

1st degree AV block



QRS complexes

- **Width**

- Normal ($\leq 100\text{ms}$)
- Wide ($\geq 120\text{ms}$)

- **Mean frontal plane axis**

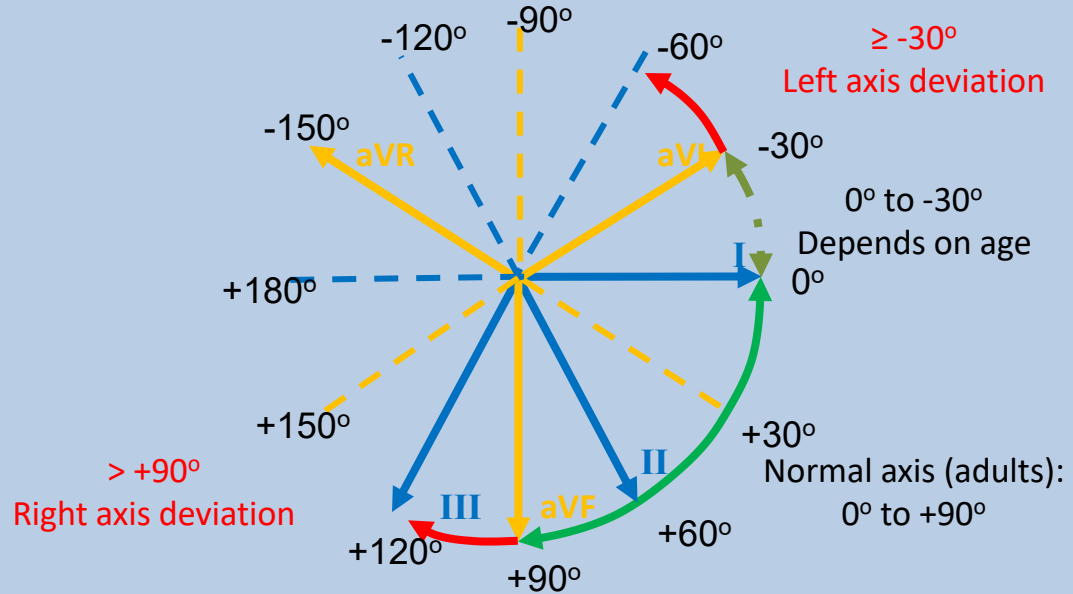
- Normal – 0 to $+90^\circ$
- Borderline – 0 to -30° (depends on age – normal in older adults)

- **Size**

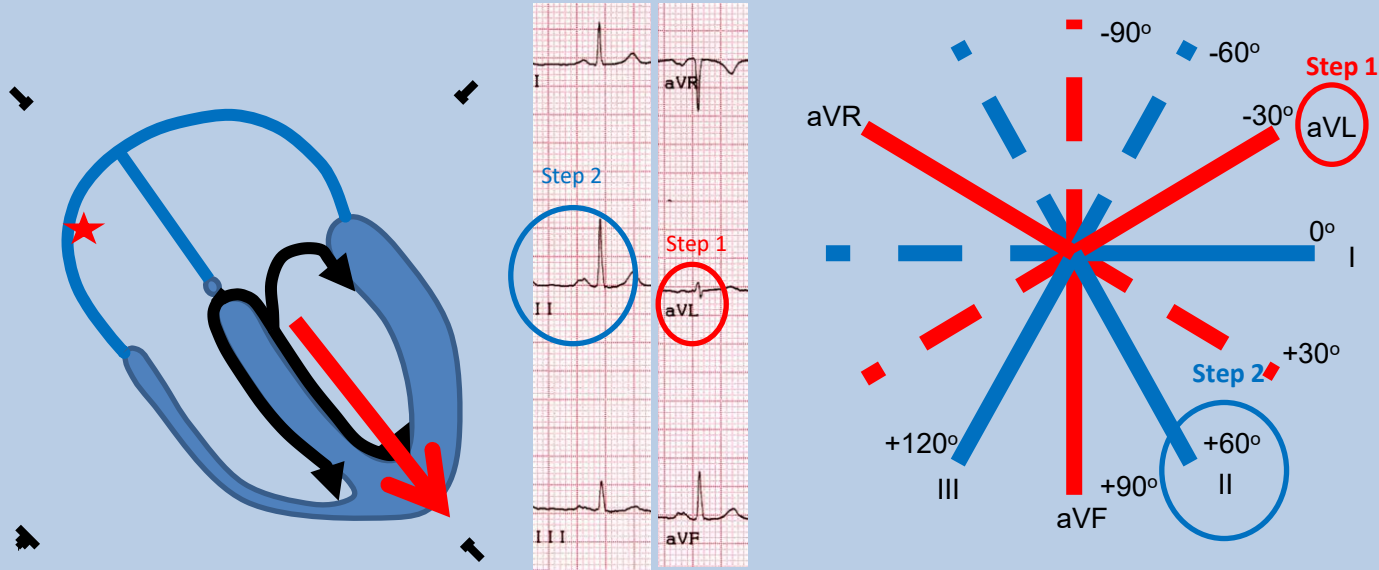
- S in V1 + R in V5 $\leq 35\text{mm}$ (3,5Mv)
- R : S ratio in V1 < 1

- **Q waves**

- Normal in aVR, V5-6 (small septal q)
- $< 40\text{ms}$ wide and $< 25\%$ of QRS height in limb leads



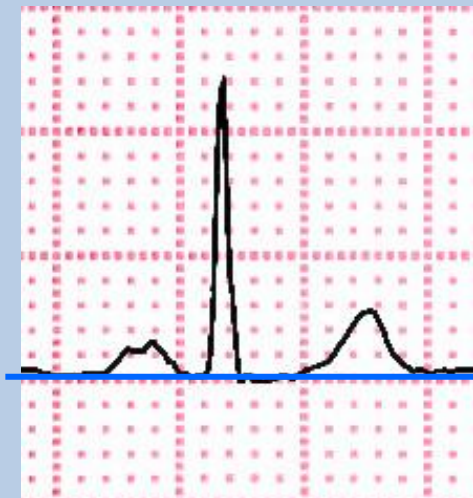
Mean frontal plane QRS axis



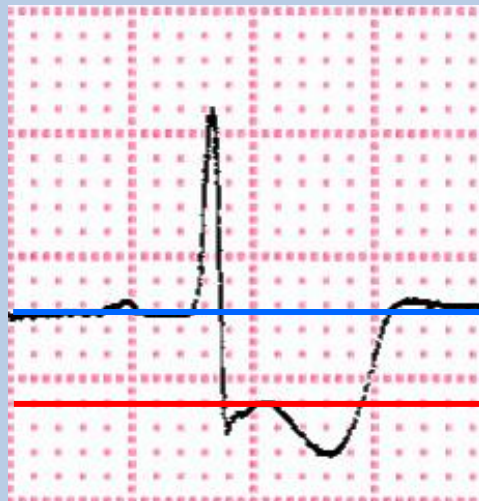
aVL is equiphase,
therefore the axis is
perpendicular to aVL

Lead II is at 90° to aVL;
the axis is therefore
parallel to II. II is
positive, therefore the
axis is $+60^\circ$.

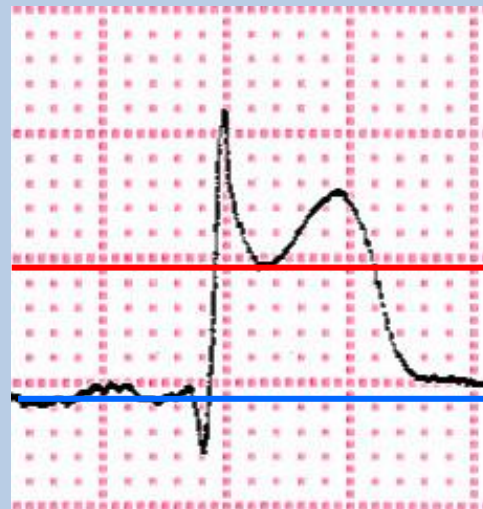
ST segments



Normal



Depressed

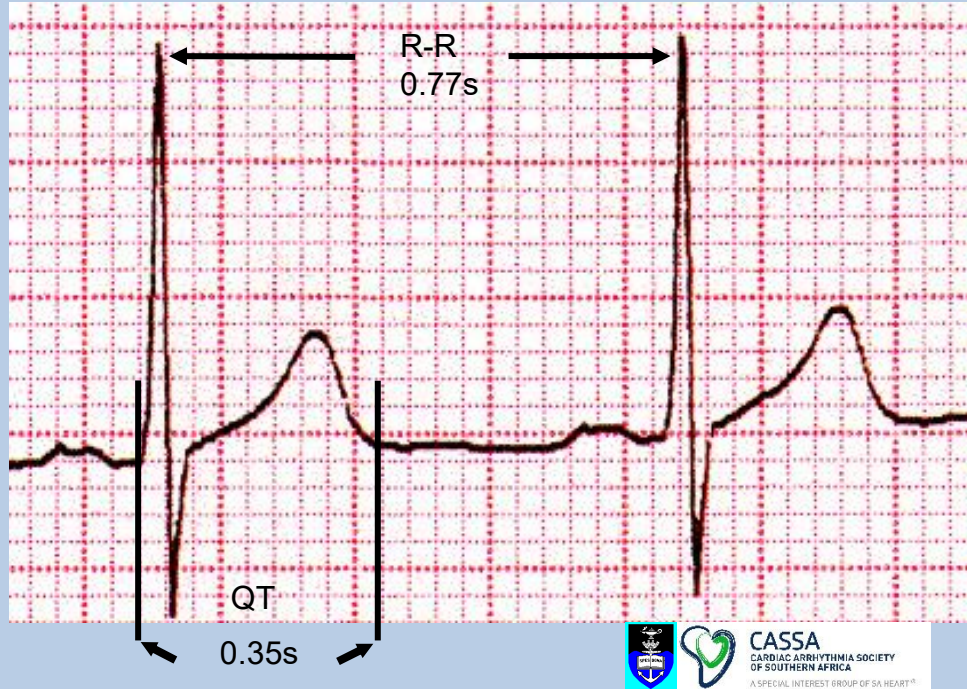


Elevated

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

$$QTc = \frac{QT}{\sqrt{R-R}}$$
$$\frac{0.35s}{\sqrt{0.77s}} = 0.39s$$

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

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 are usually benign

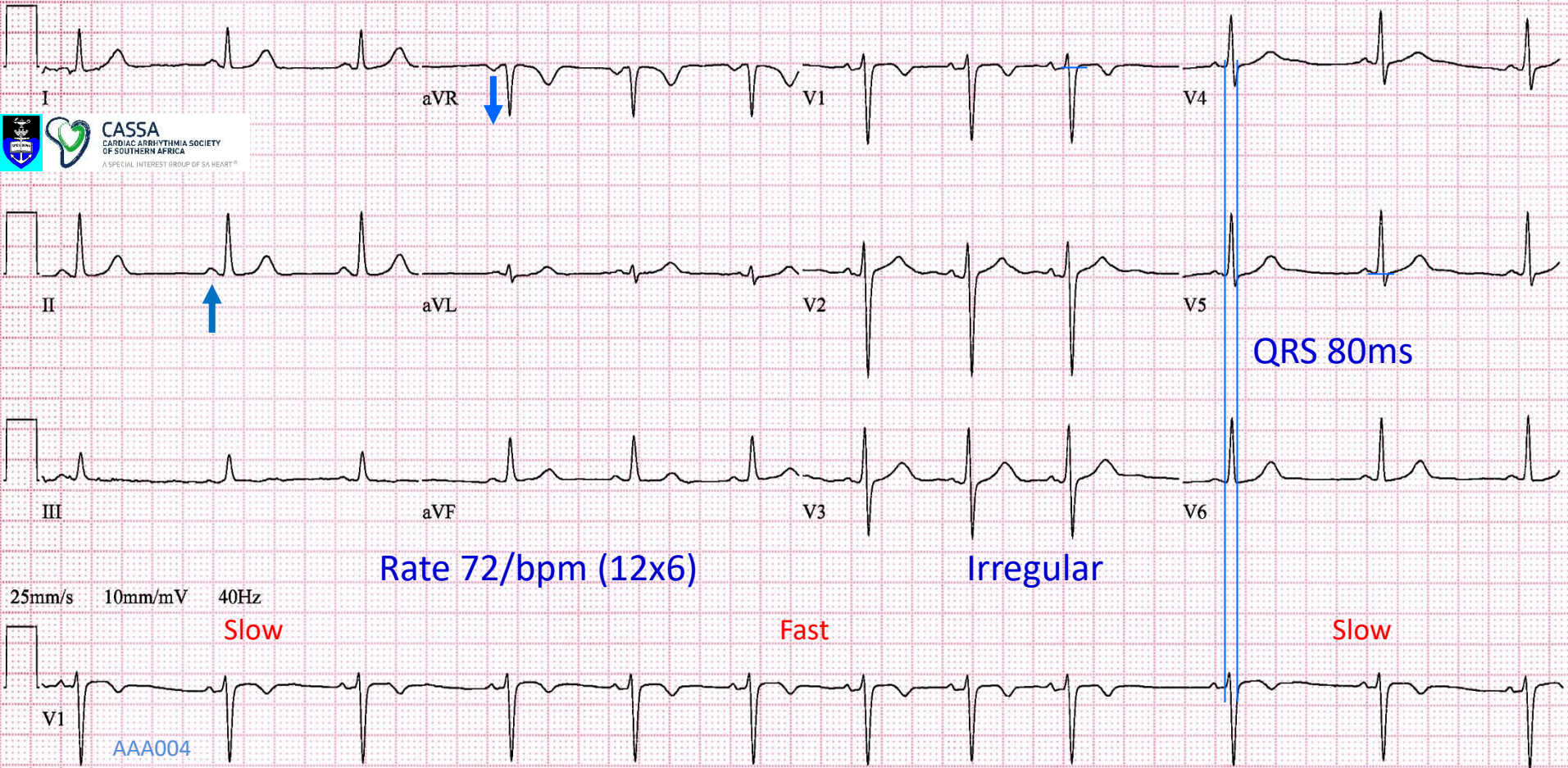


Is this ECG:

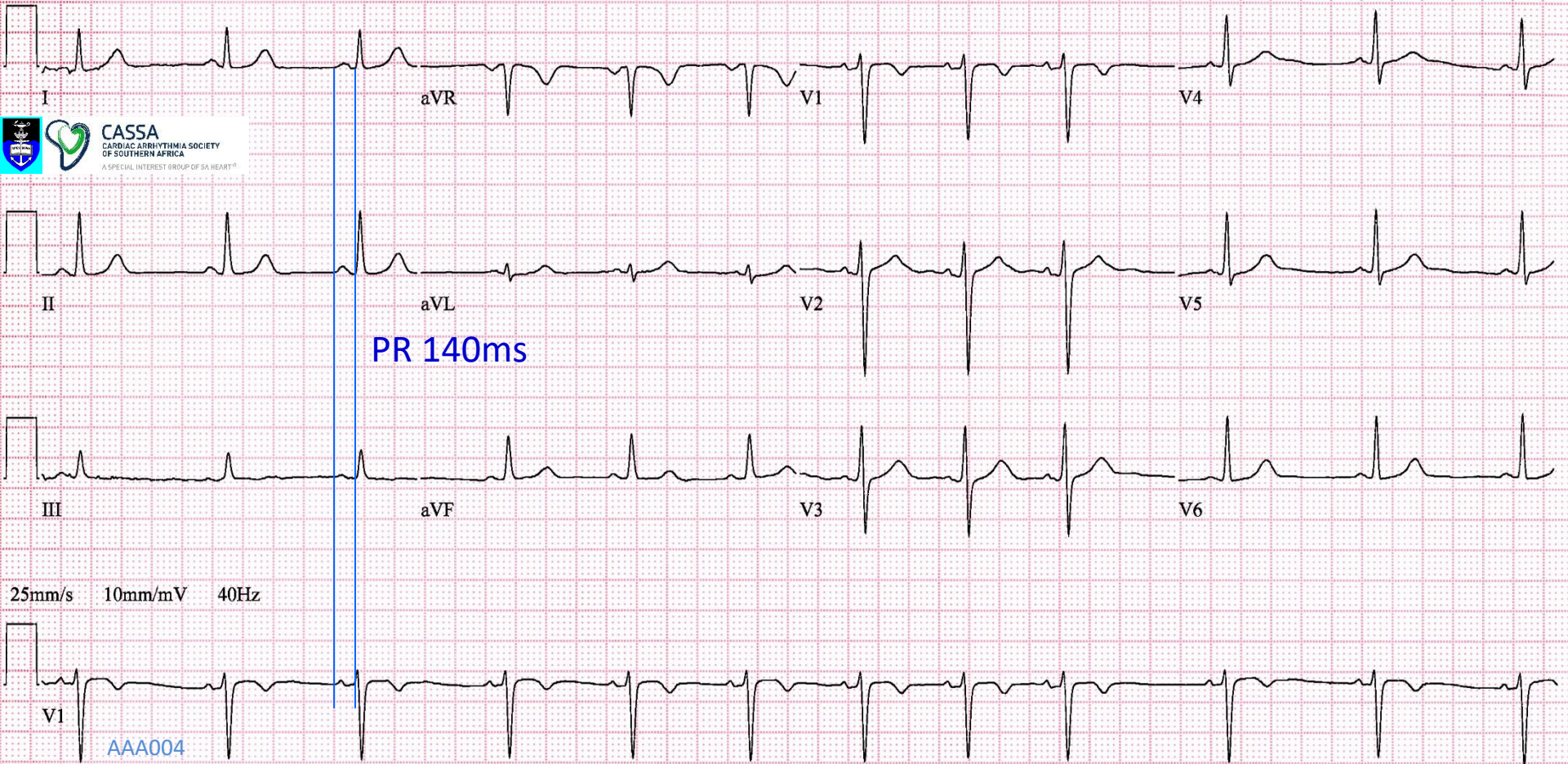
- a) Normal?
- b) Abnormal?

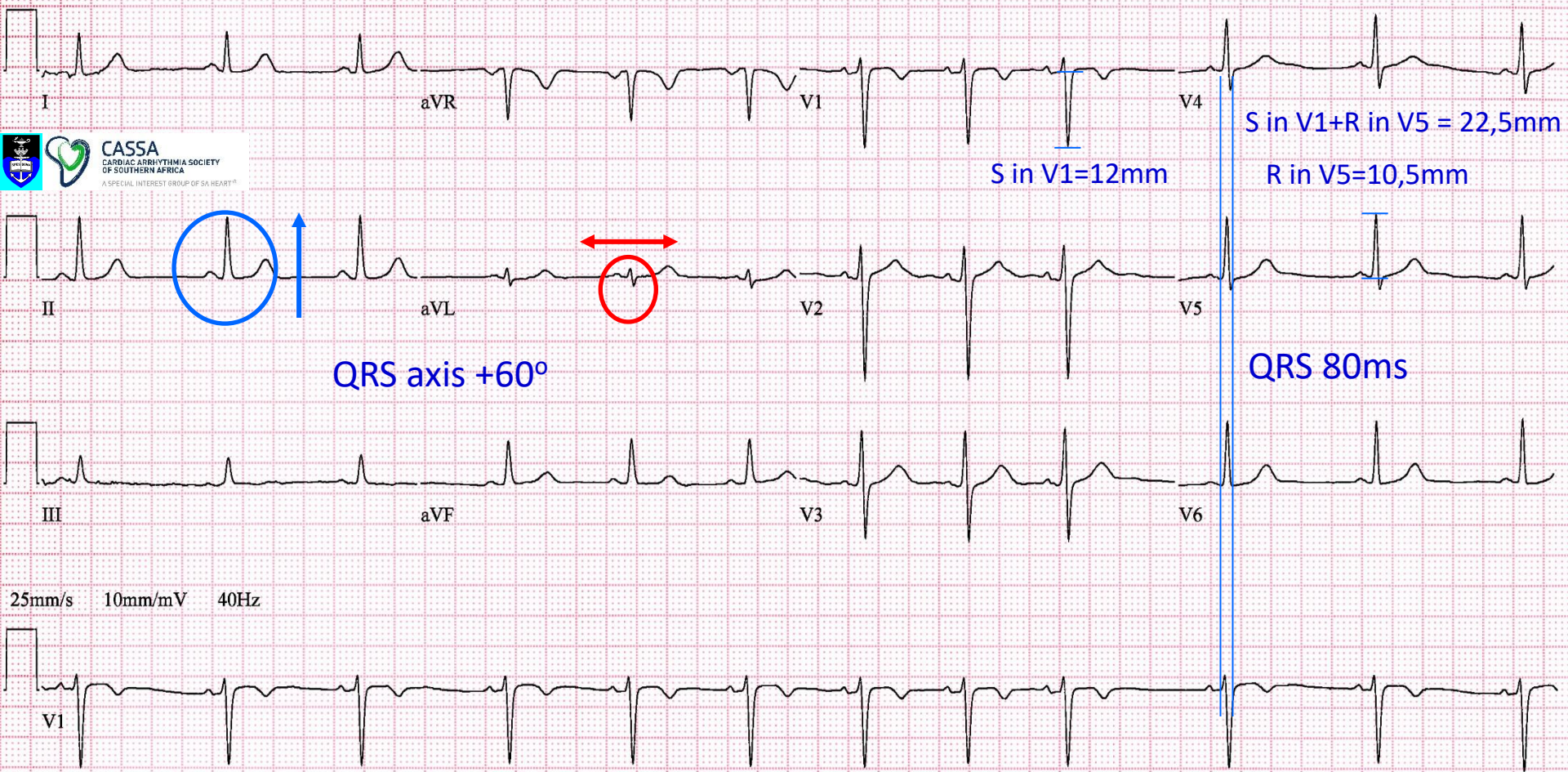
25mm/s 10mm/mV 40Hz

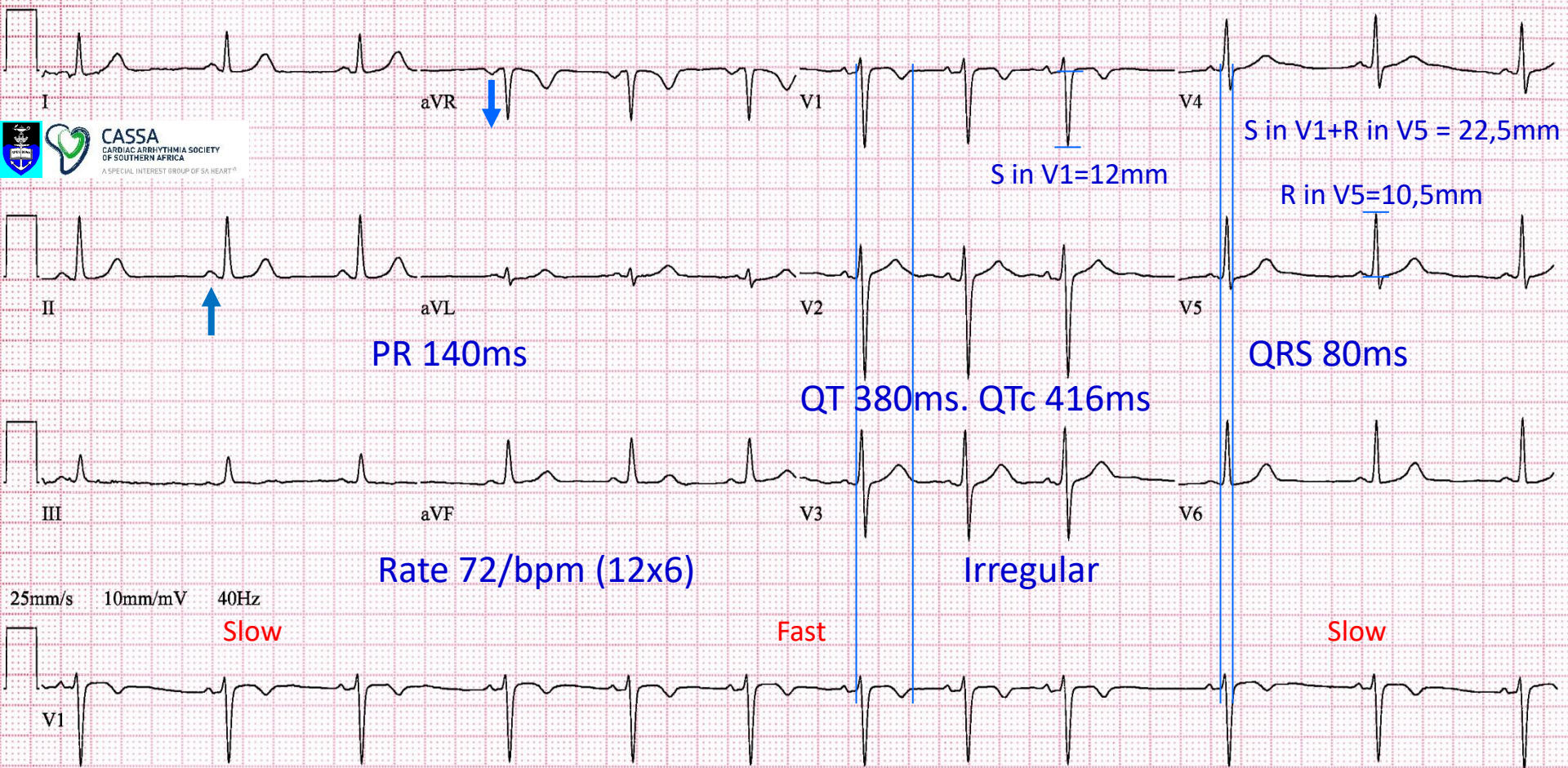




Sinus arrhythmia



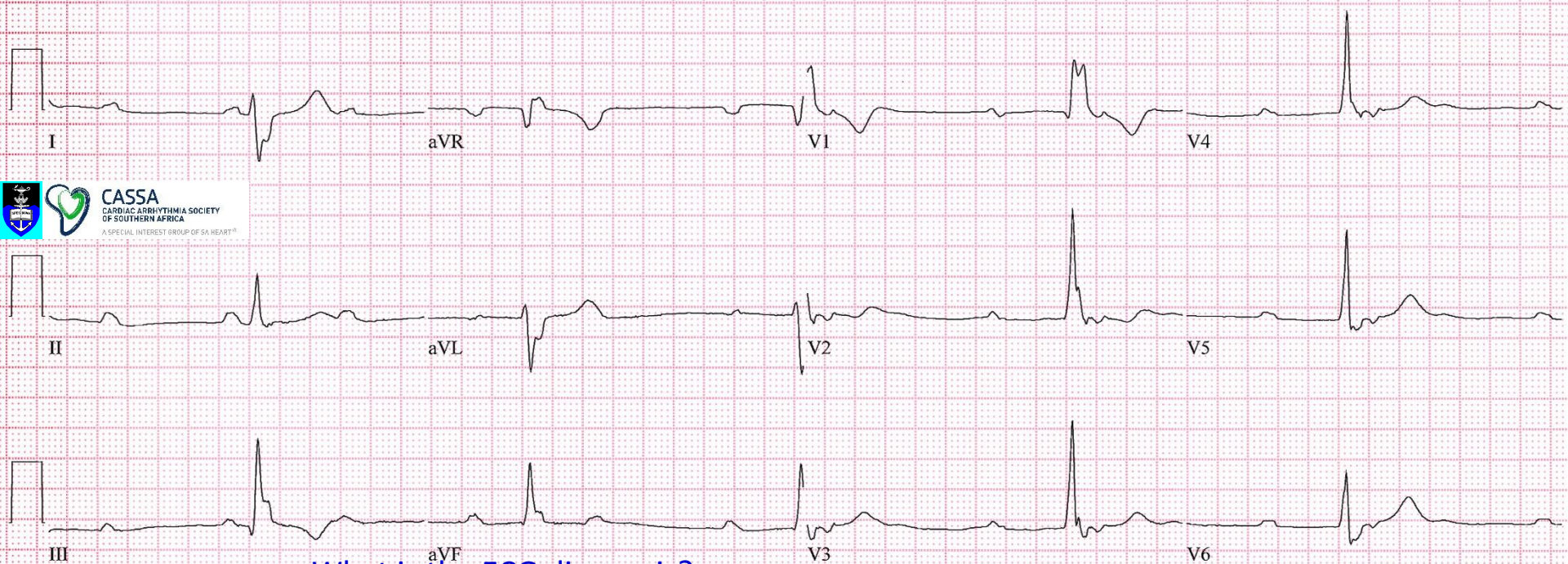




Normal ECG – sinus arrhythmia

Normal Adult ECG values

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

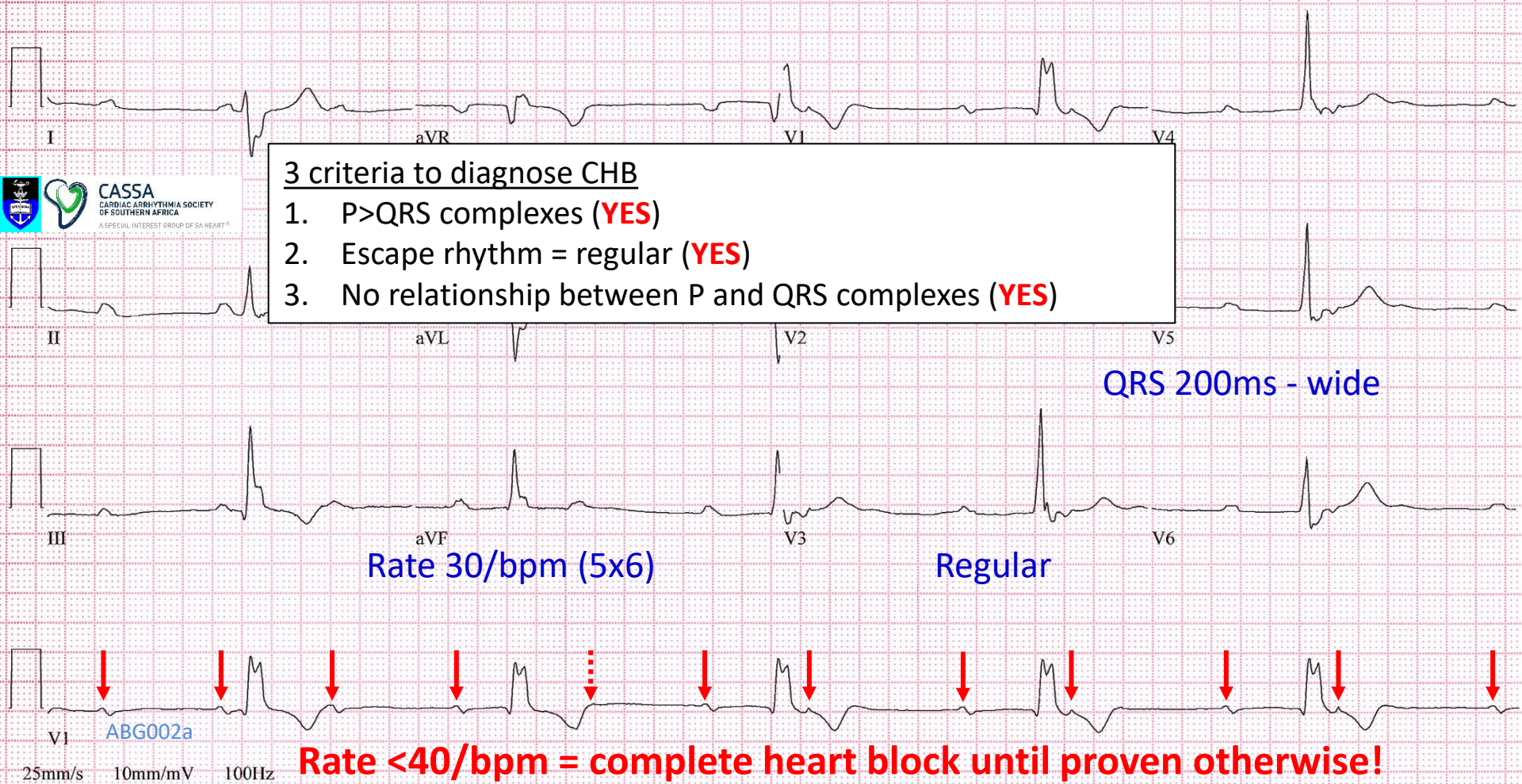


What is the ECG diagnosis?:

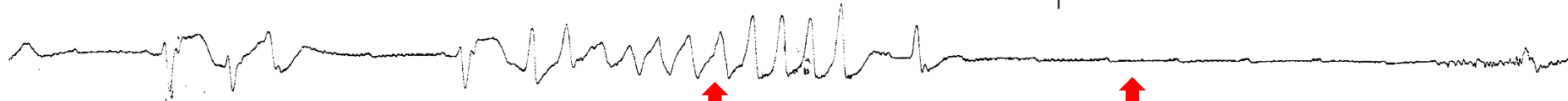
- a) Sinus bradycardia with RBBB
- b) Sinus bradycardia with RBBB + first degree AV block



- c) Complete heart block
- d) Sinus bradycardia with right ventricular hypertrophy

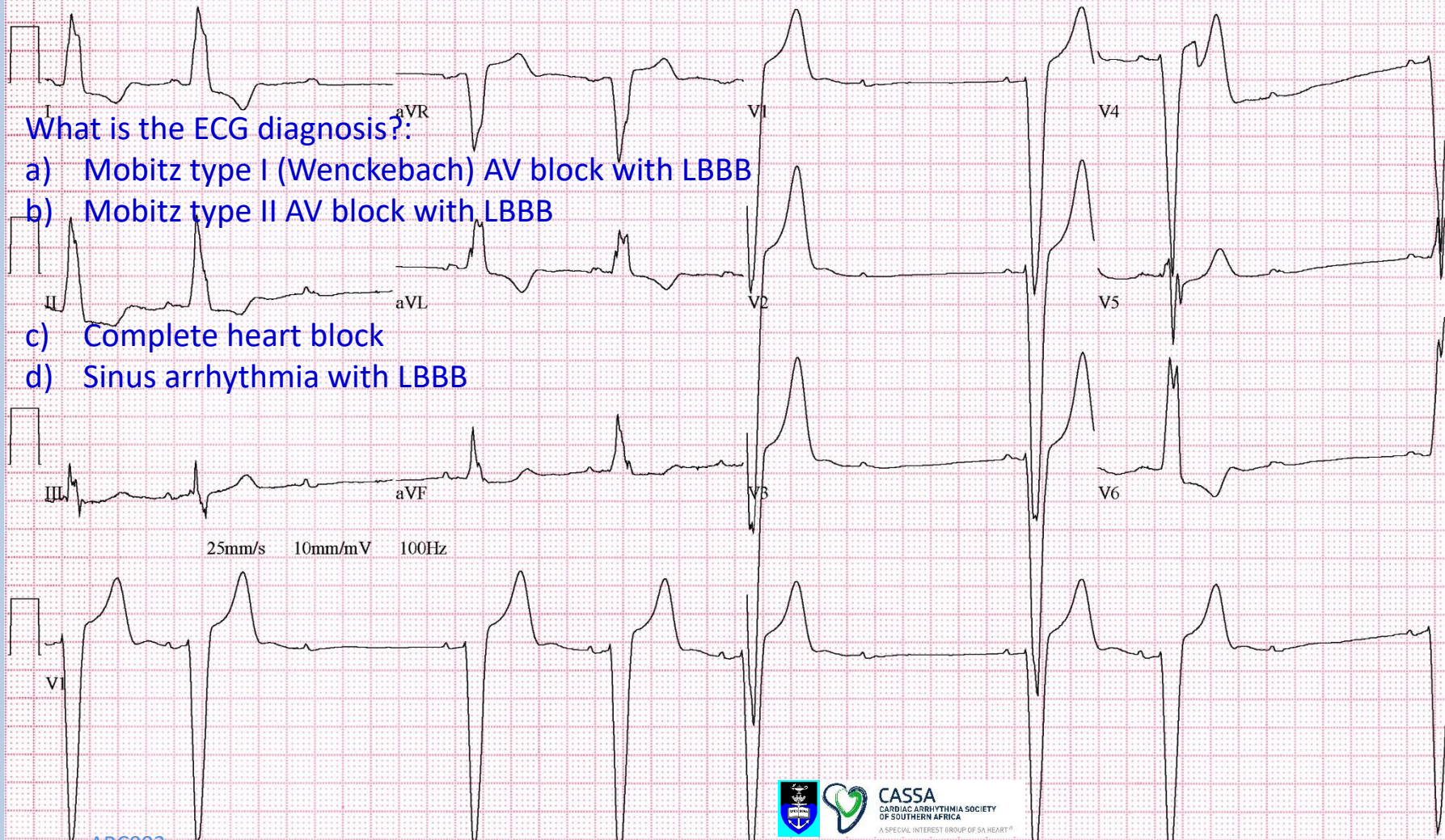


Complete heart block is a medical emergency and patients should be referred for urgent pacing



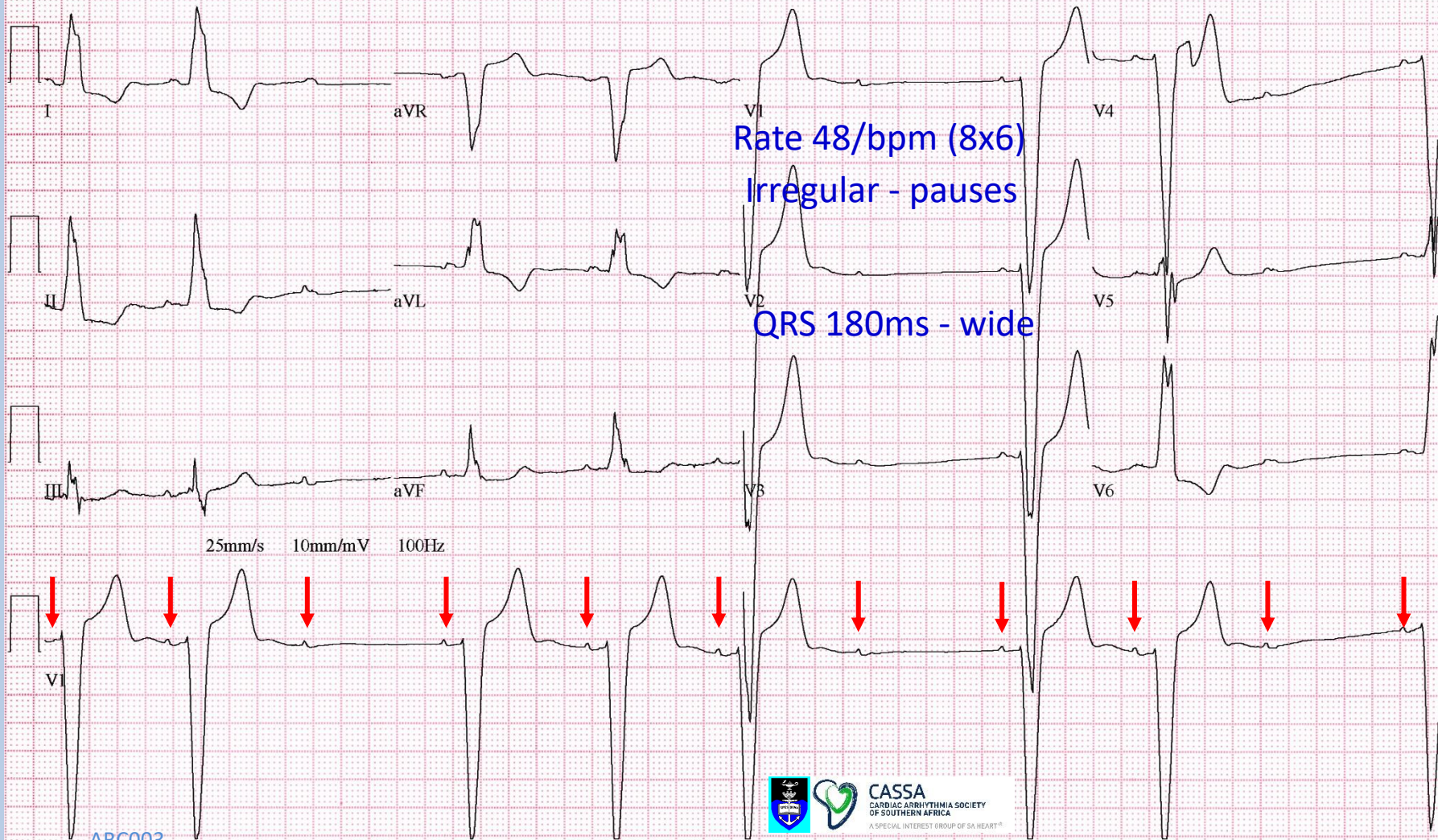
Mechanisms of death with CHB:

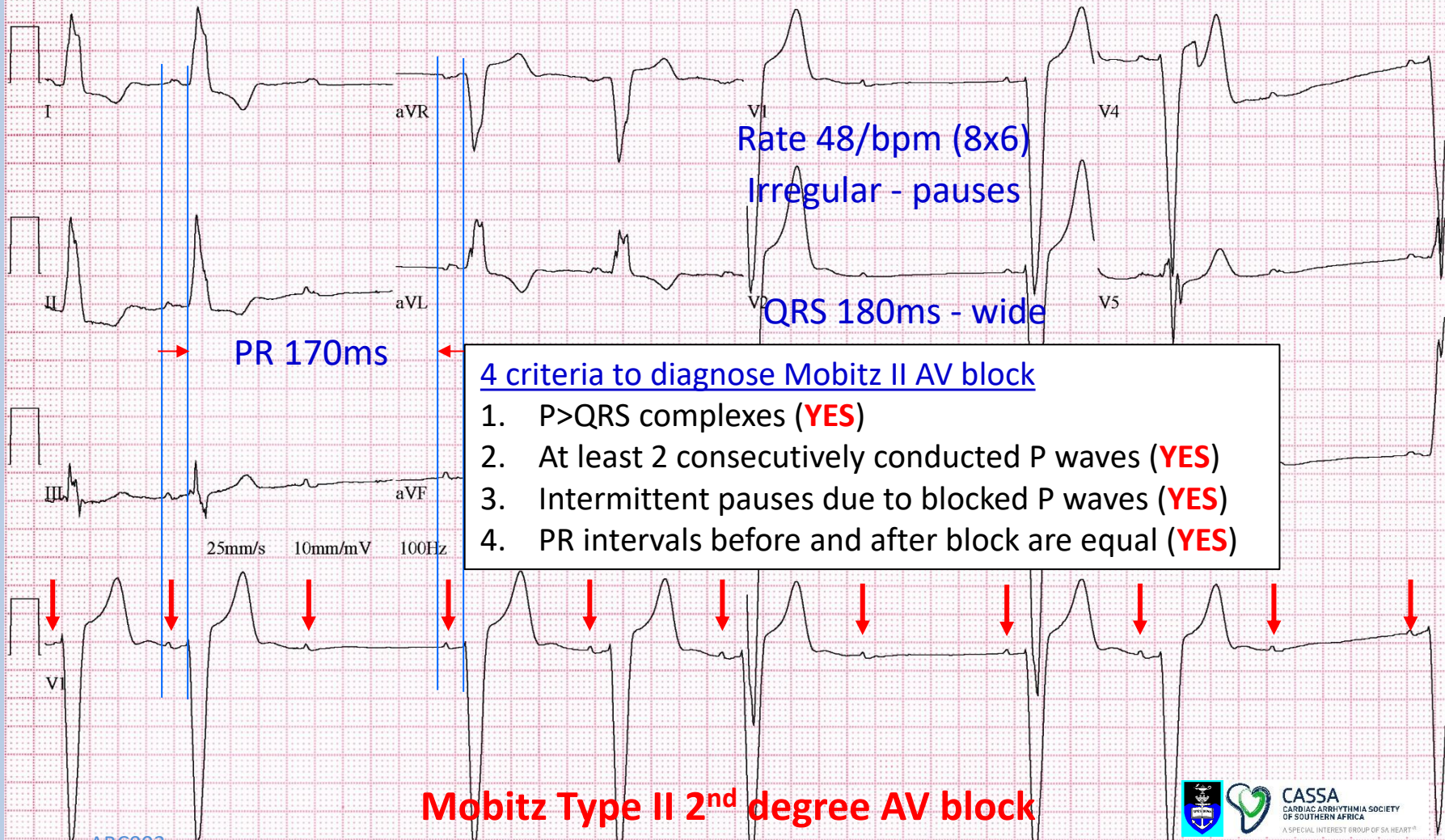
1. Pause-dependent Torsades de Pointes
2. Asystole (ventricular escape rhythm fails)



What is the ECG diagnosis?:

- a) Mobitz type I (Wenckebach) AV block with LBBB
- b) Mobitz type II AV block with LBBB
- c) Complete heart block
- d) Sinus arrhythmia with LBBB





Rate 48/bpm (8x6)

Irregular - pauses

QRS 180ms - wide

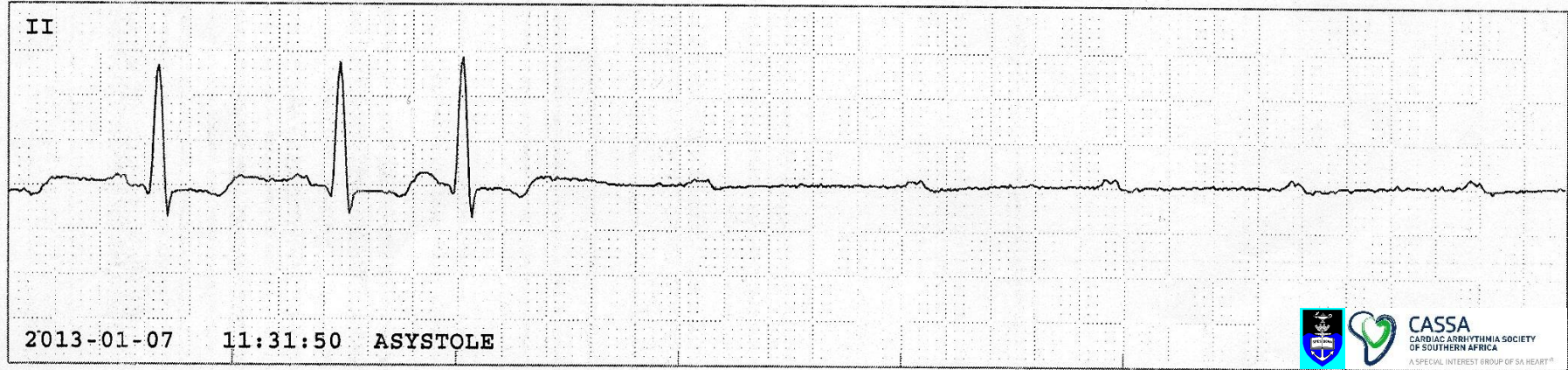
PR 170ms

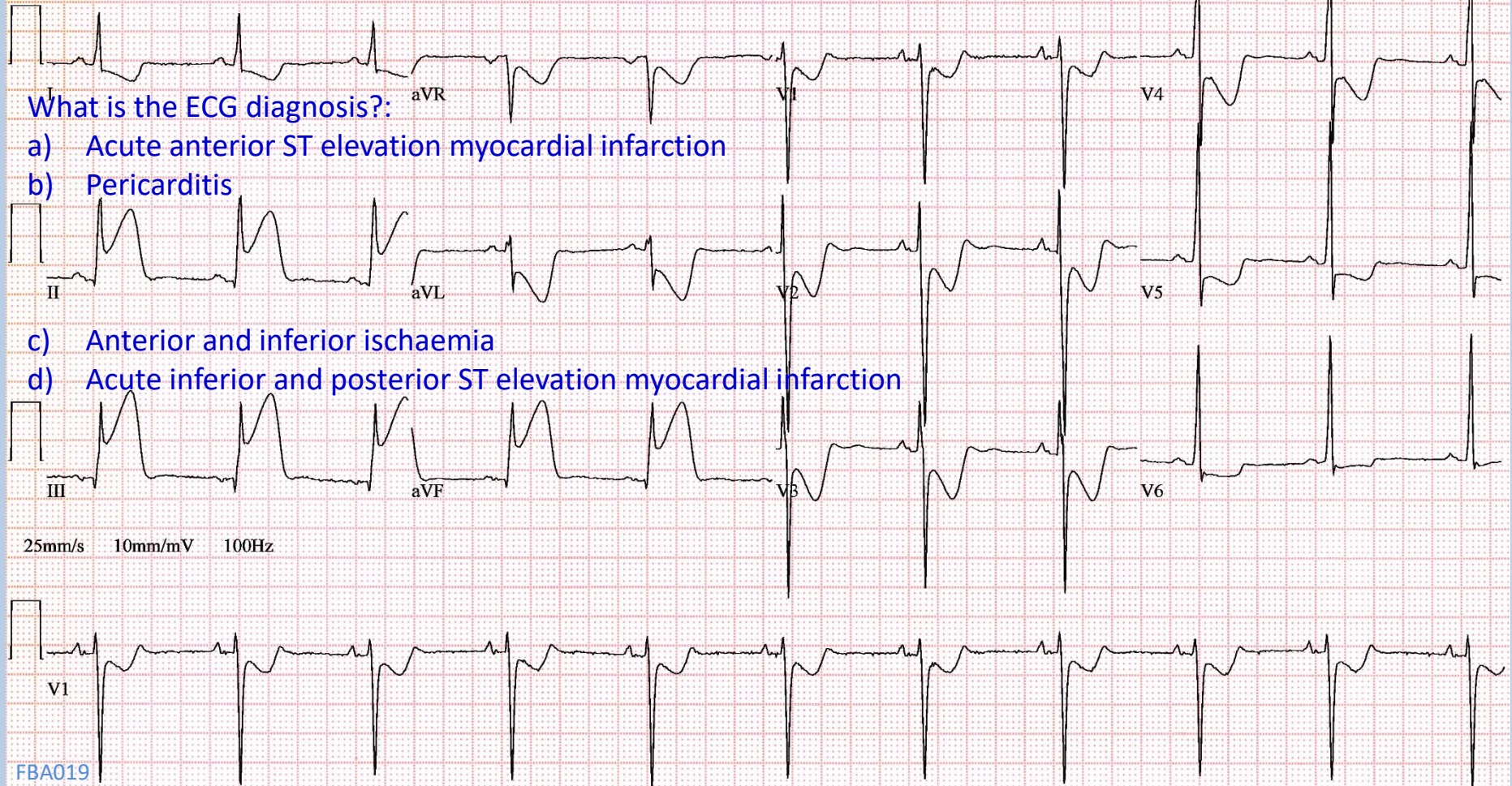
4 criteria to diagnose Mobitz II AV block

1. P > QRS complexes (YES)
2. At least 2 consecutively conducted P waves (YES)
3. Intermittent pauses due to blocked P waves (YES)
4. PR intervals before and after block are equal (YES)

Mobitz Type II 2nd degree AV block

Second degree heart block is a medical emergency and patients should be referred for urgent pacing

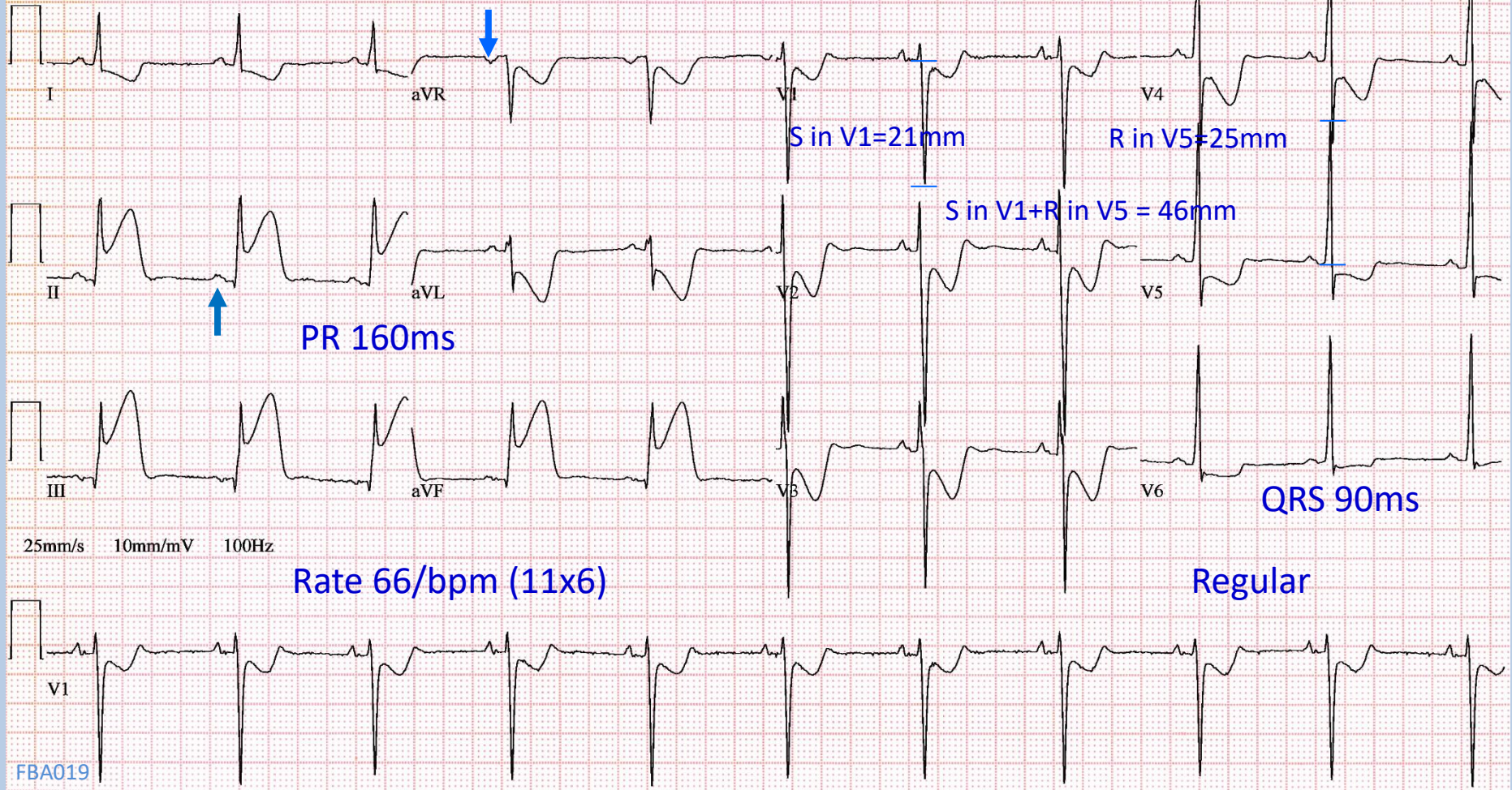


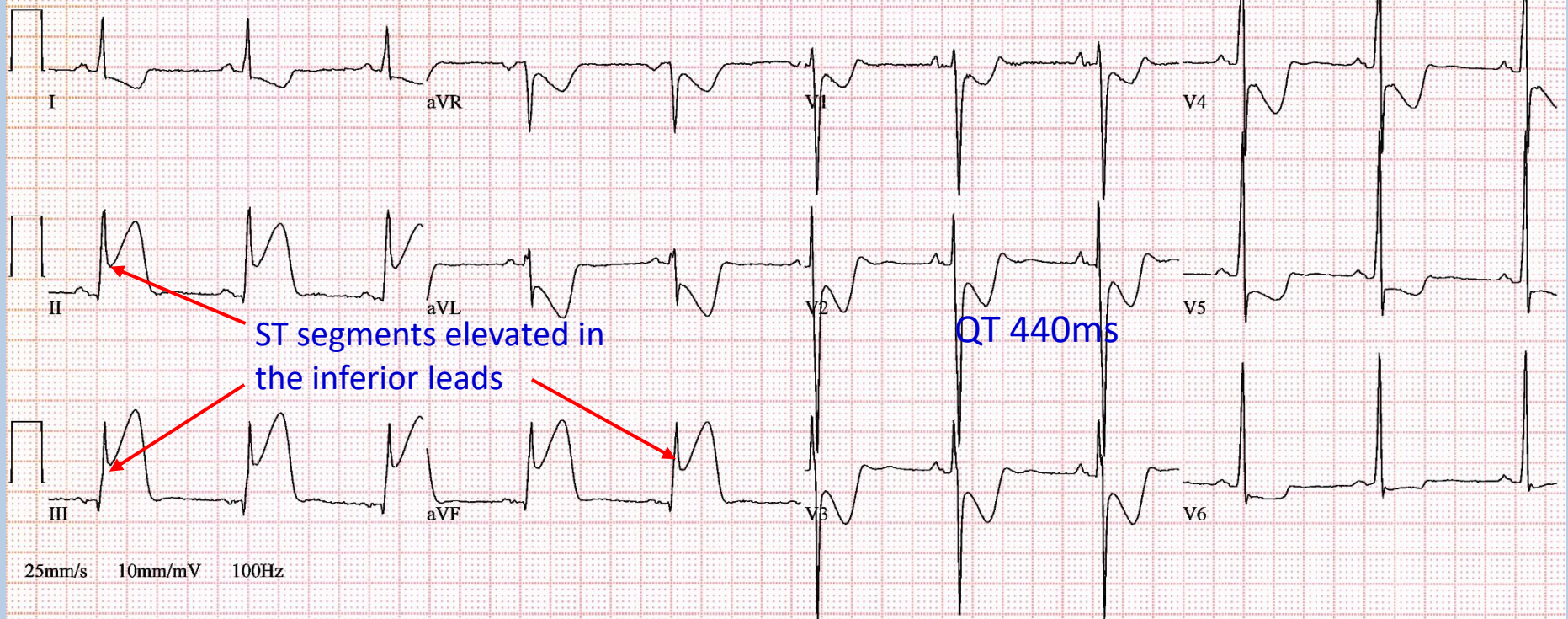


What is the ECG diagnosis?:

- a) Acute anterior ST elevation myocardial infarction
- b) Pericarditis
- c) Anterior and inferior ischaemia
- d) Acute inferior and posterior ST elevation myocardial infarction

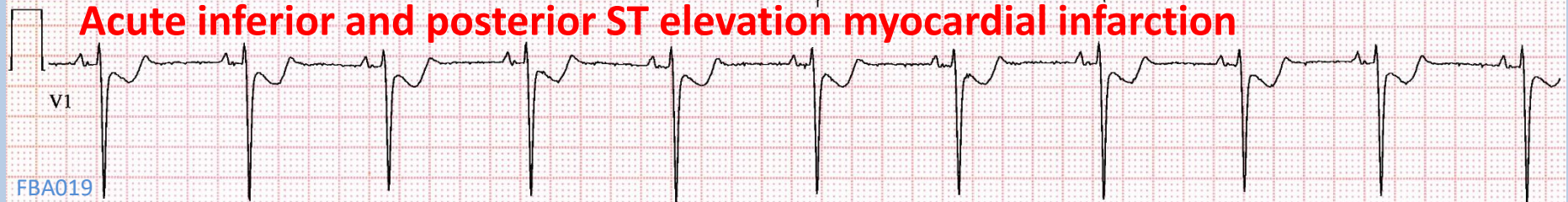
25mm/s 10mm/mV 100Hz

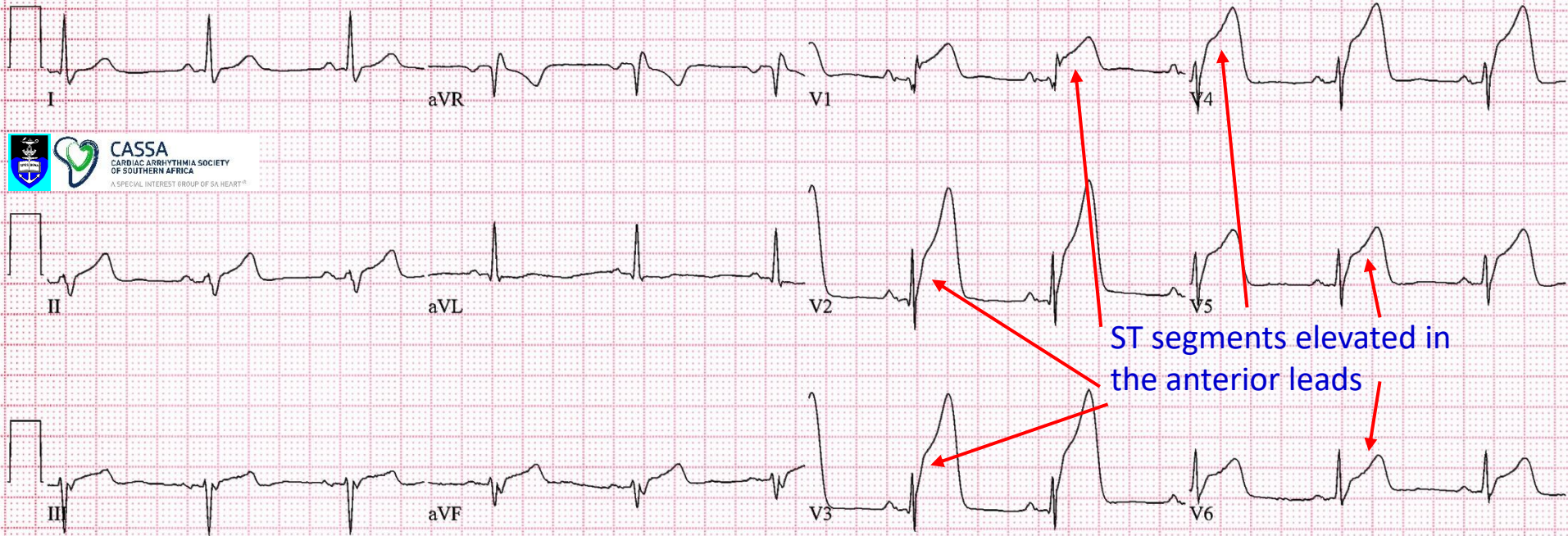




25mm/s 10mm/mV 100Hz

Acute inferior and posterior ST elevation myocardial infarction



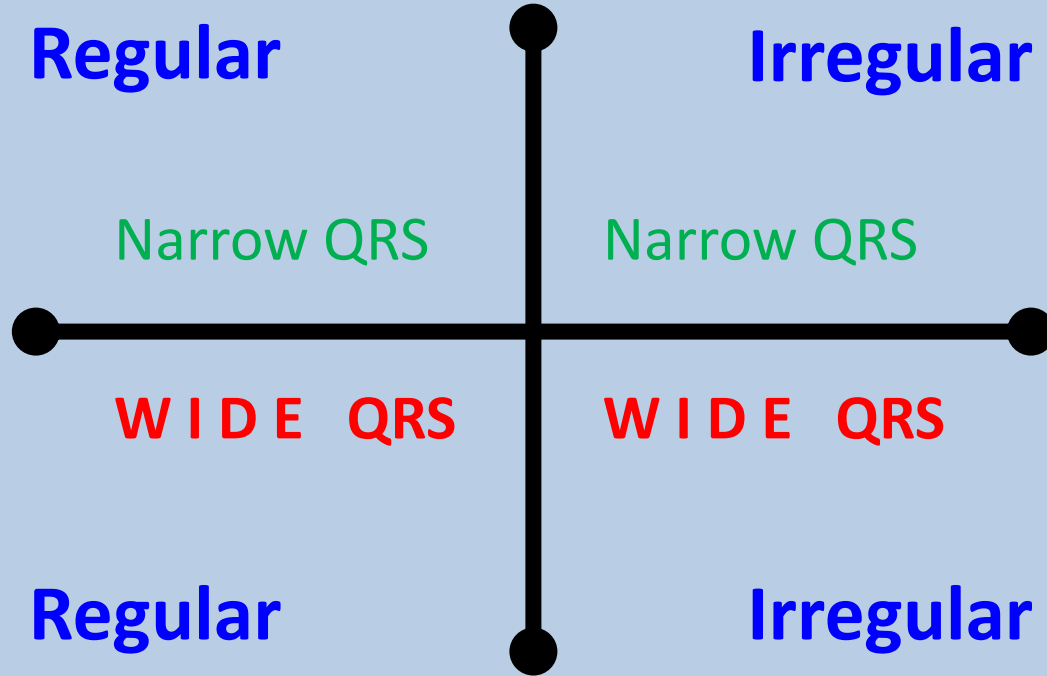


Acute anterior ST elevation myocardial infarction



25mm/s 10mm/mV 100Hz

TACHYARRHYTHMIAS



TACHYARRHYTHMIAS

Regular

Narrow QRS

Sinus tachycardia
Atrial flutter
AVJRT (AVNRT, AVRT)
Atrial tachycardia
Junctional ectopic tachycardia

Irregular

Narrow QRS

Atrial Fibrillation
Atrial flutter/tachy + variable AVB
Multifocal atrial tachycardia

Ventricular tachycardia

SVT with BBB
SVT with IVCD
Paced rhythm
Antidromic AVRT
Pre-excited SVT

AF with BBB

A flutter/tachy + variable AVB + BBB
Preexcited AF
Polymorphic VT

Regular

WIDE QRS

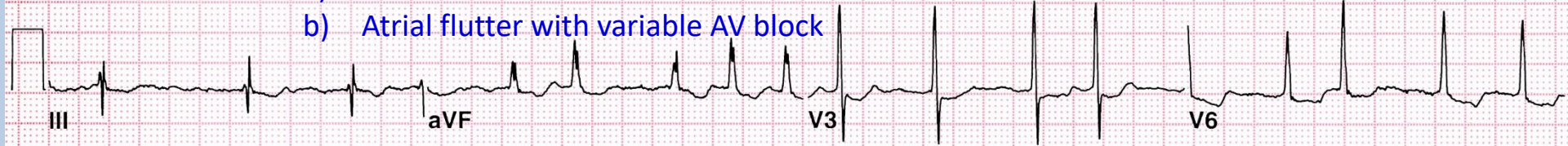
WIDE QRS

Irregular



What is the ECG diagnosis?:

- a) Atrial fibrillation
- b) Atrial flutter with variable AV block

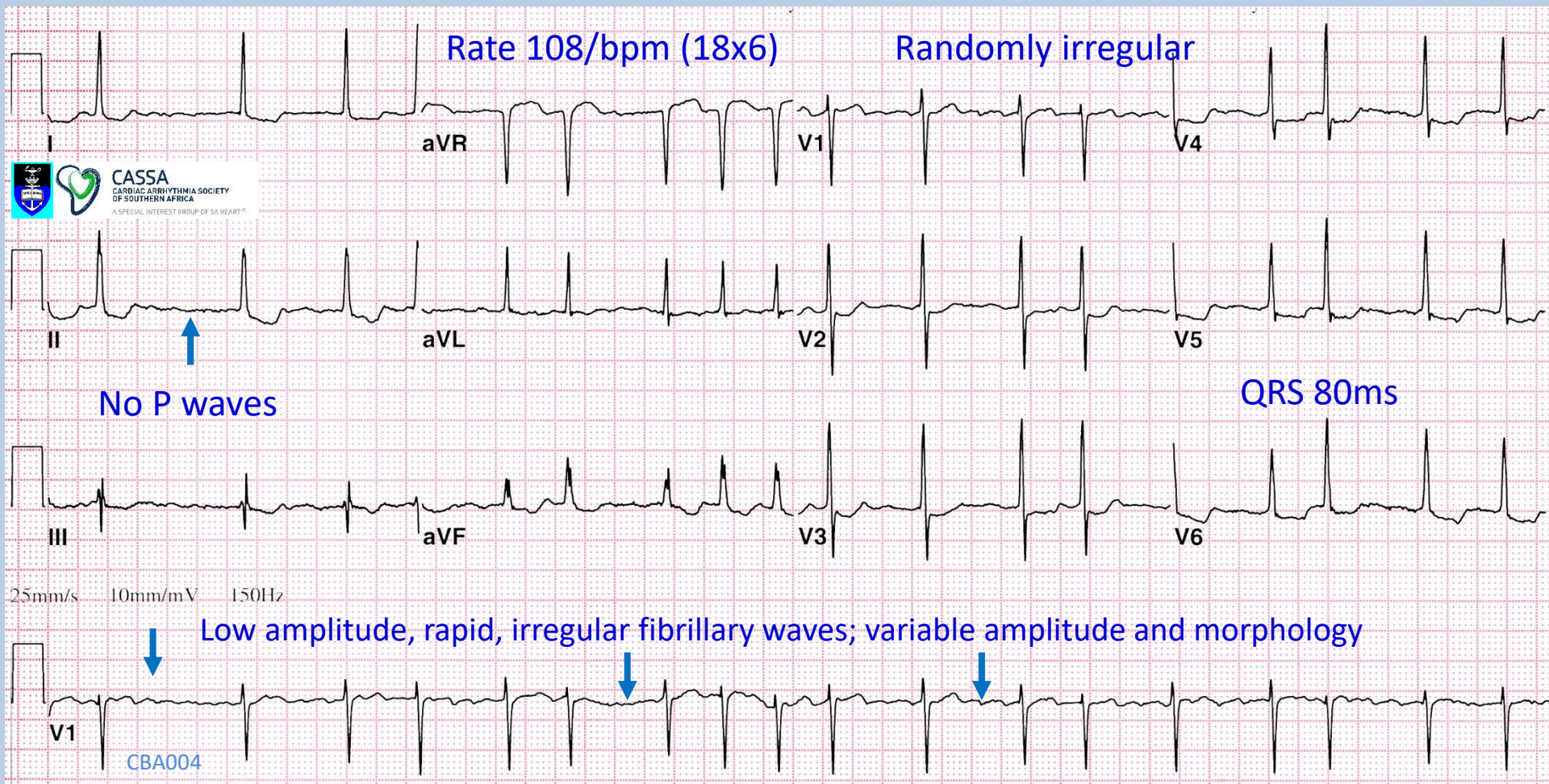


25mm/s 10mm/mV 150Hz

- c) Atrial tachycardia with variable AV block
- d) Multifocal atrial tachycardia



CBA004

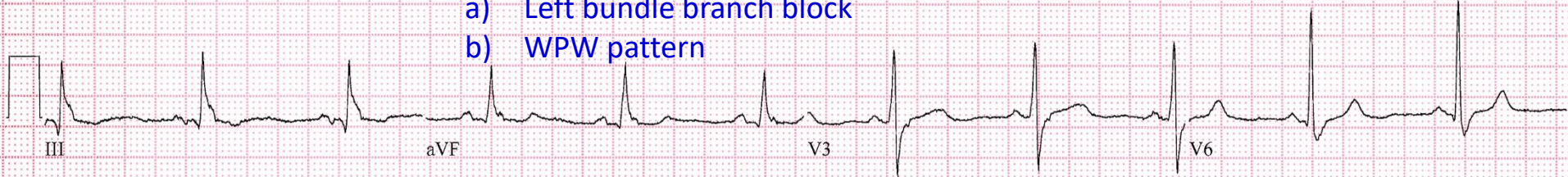


Randomly irregular, narrow QRS tachycardia: Default diagnosis = atrial fibrillation



What is the ECG diagnosis?:

- a) Left bundle branch block
- b) WPW pattern

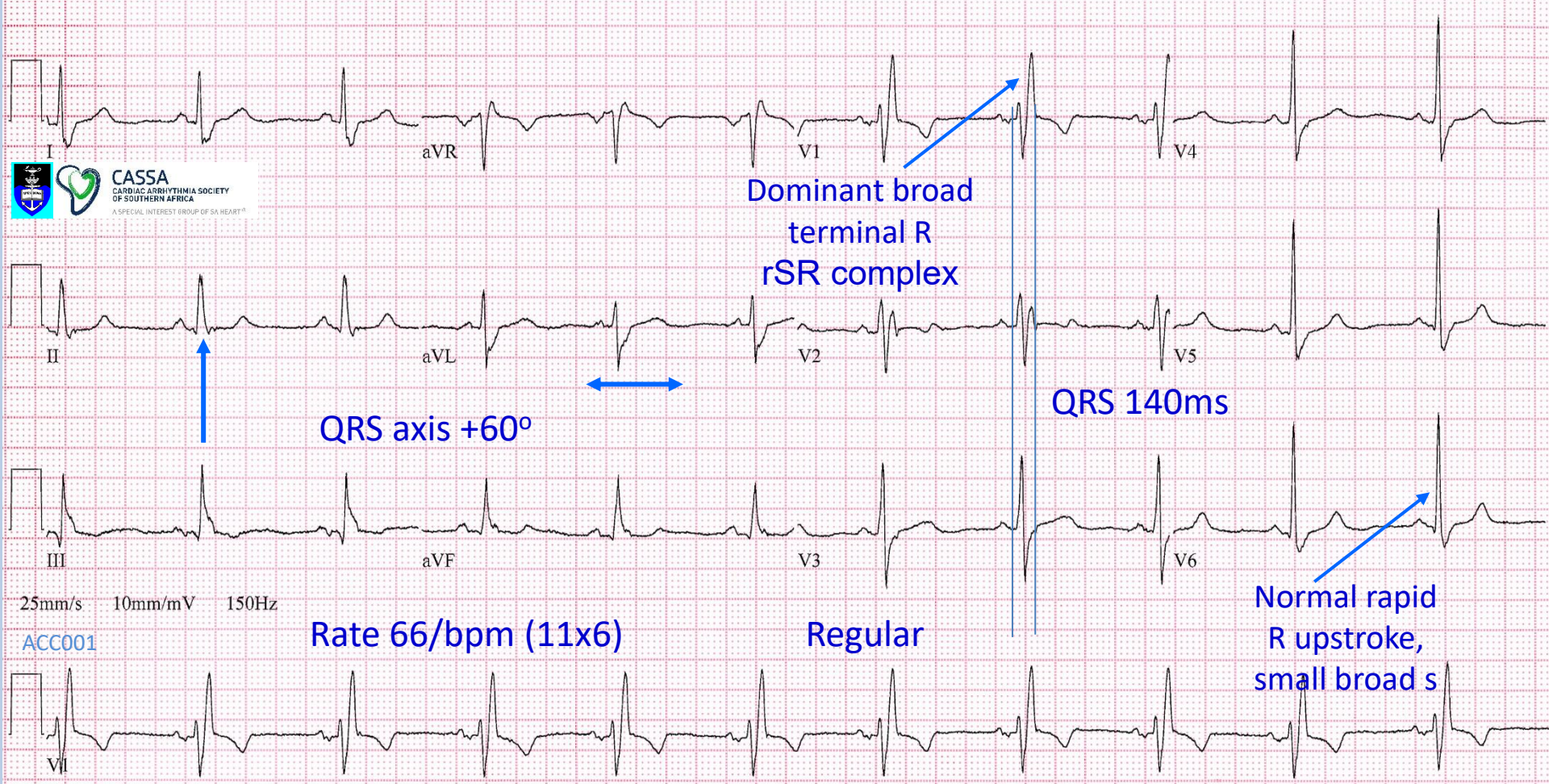


25mm/s 10mm/mV 150Hz

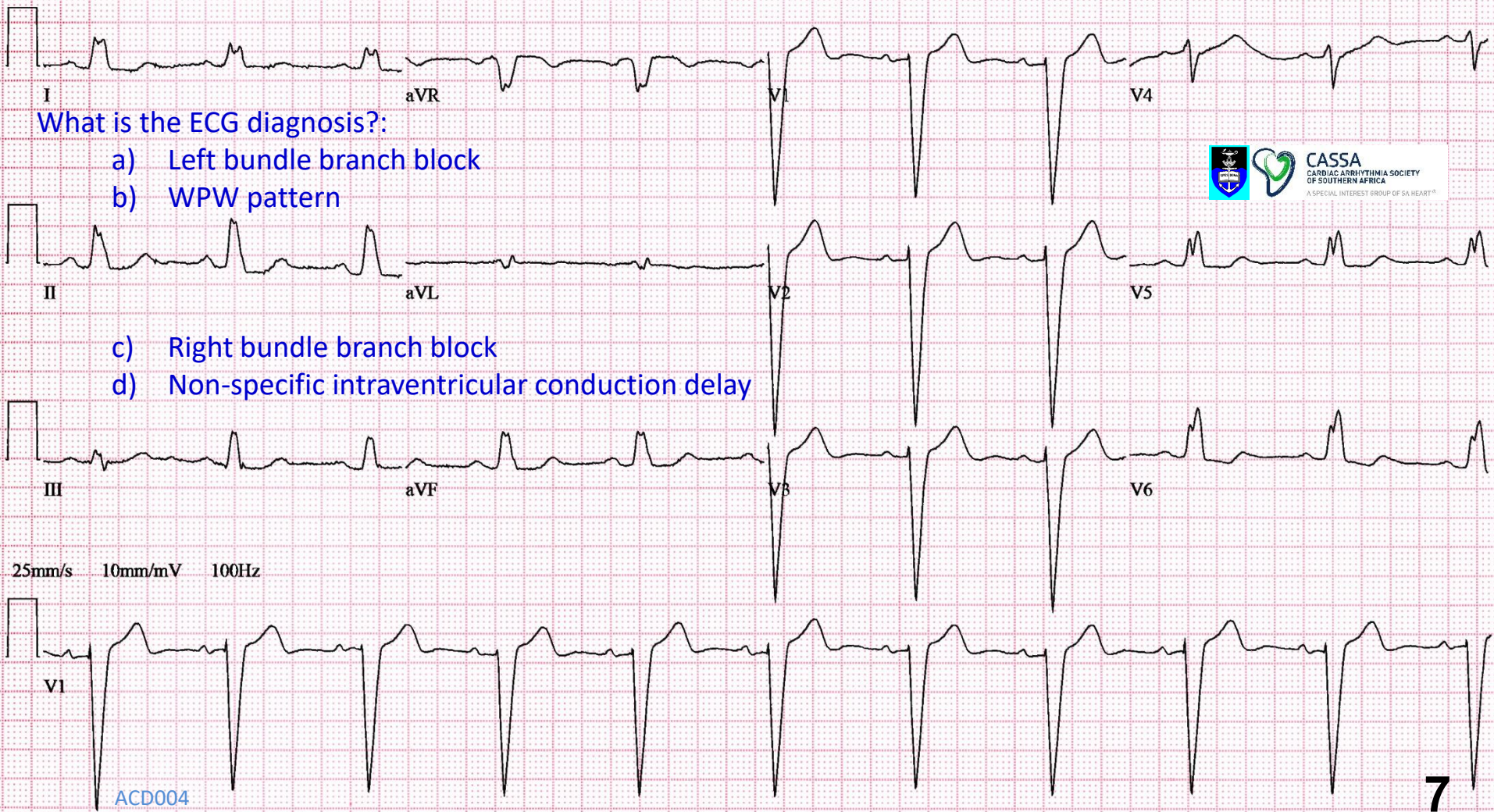
ACC001

- c) Right bundle branch block
- d) Non-specific intraventricular conduction delay



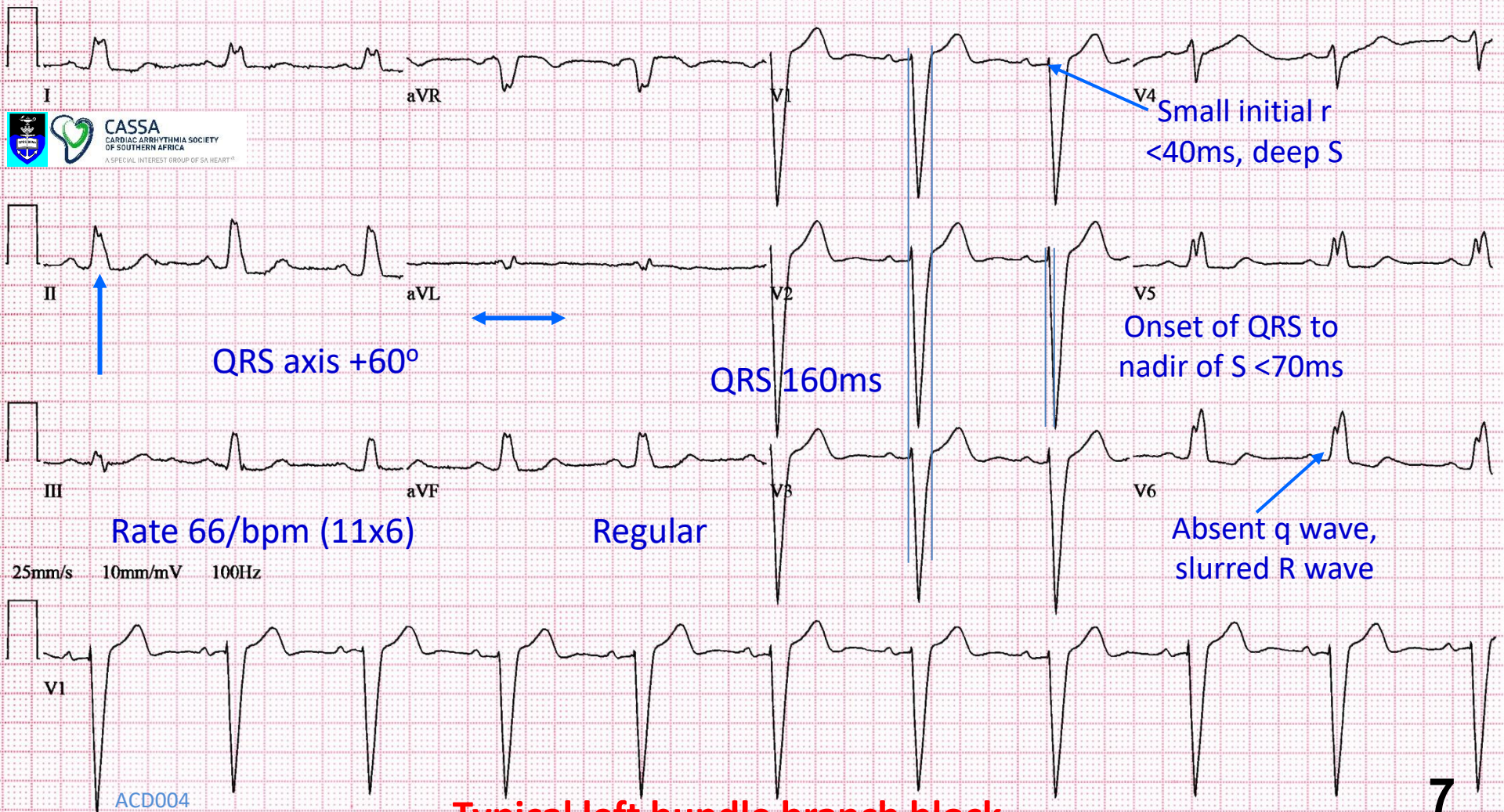


Typical right bundle branch block



What is the ECG diagnosis?:

- a) Left bundle branch block
- b) WPW pattern
- c) Right bundle branch block
- d) Non-specific intraventricular conduction delay



Typical left bundle branch block

Summary

- Approach to ECG analysis
 - Overview
 - Rate, rhythm (regular or irregular), QRS width
 - Systematic analysis
- Examples of essential ECGs
 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
- Next module: 7 more ECGs

- Free download
- 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

Free app for download

ECG

APPtitude



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

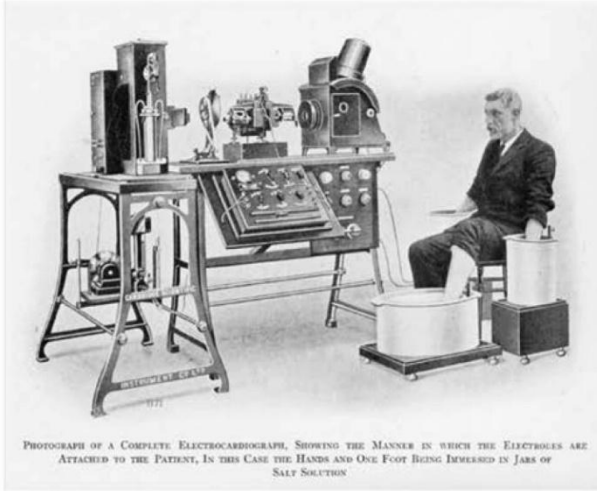
The ECG Atlas of Cardiac Rhythms

This book contains around 95 full size 12 lead ECGs which are analysed in detail. It covers all the rhythms you are likely to see in practice grouped into:

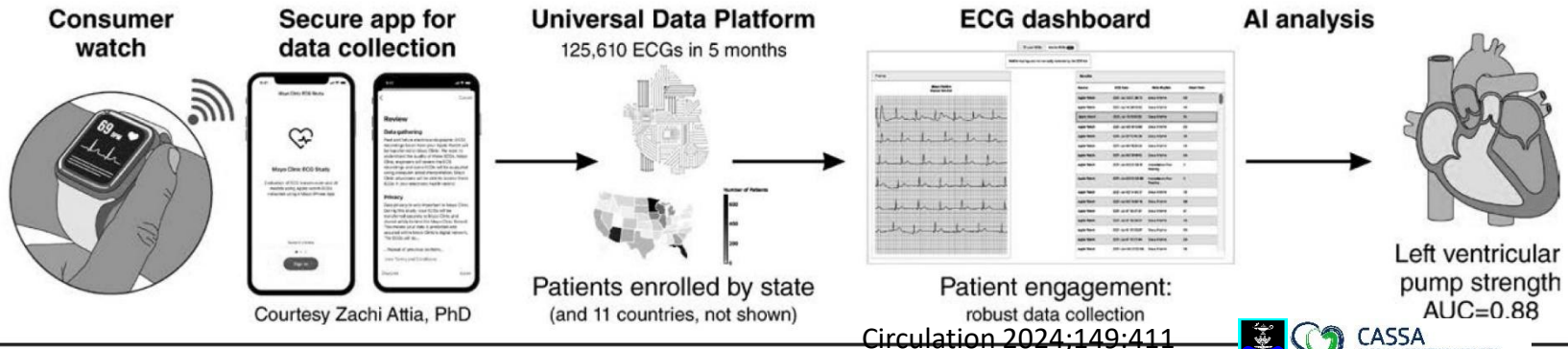
- Bradycardias and conduction disturbances
- Abnormal rhythms at normal rates (including paced)
- Narrow QRS tachycardias
- Wide QRS tachycardias

Rob Scott Millar

To get the book, go to: <http://www.ecgrhythmsatlas.com/>

A

1903 – Willem Einthoven

B**Figure. The evolution of the ECG.**AI indicates artificial intelligence; App, application; and AUC, area under the curve. **A** is in the public domain (PD-US).

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