Webinar – 19th November 2025, Module 3

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Essential ECGs

ECGs that matter

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Summary

- Approach to ECG analysis
  - Overview
  - Rate, rhythm (regular or irregular), QRS width
  - Systematic analysis
- Examples of essential ECGS (Modules 1 & 2, see CASSA website)
  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
  8. Ventricular tachycardia
  9. Left ventricular hypertrophy
  10. Right ventricular hypertrophy
  11. Atrial flutter
  12. AVNRT/AVRT
  13. WPW pattern
  14. Congenital long QT syndrome
- This module: 7 more ECGs

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What can you learn from an ECG?

- **Rhythm**
- **Conduction**
- Structural heart disease
  - Myocardial infarction
  - Hypertrophy
    - Atria
    - Ventricles
  - Pericarditis
- **Pre-excitation syndromes**
  - WPW syndrome
- **Genetic abnormalities**
  - Congenital long QT syndrome
  - Brugada syndrome
- Transient abnormalities
  - Ischaemia
  - Electrolytes

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Who should have an ECG?

- Acute chest pain
- Arrhythmia
- Unexplained blackouts
- Dyspnoea, unusual fatigue
- Jaw pain
- Chest discomfort related to exercise
- Suspected heart disease
- Hypertension
- Major medical/surgical illness
- Drug overdose
- Stroke
- Patients over 50
- Routine check up

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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**

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Some examples of “Essential ECGs”
ECGs critical to the diagnosis

- **Lethal conditions**
  - Ventricular fibrillation
  - 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
  - Brugada pattern
  - Long QT
- **Useful for prognosis**
  - Left ventricular hypertrophy
  - Right ventricular hypertrophy

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Initial approach to an ECG – start with the patient

- **Clinical context e.g.:**
  - Level of consciousness, chest pain, shock, 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

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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

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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/unsure
  - 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

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Beware snap ("blink") diagnoses and premature closure

Look beyond the obvious – analyse systematically

Ventricular rate

Rate = number of QRS complexes x6

Normal (60-100/min)

Slow(<60/min)

Fast(>100/min)

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Regularity

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

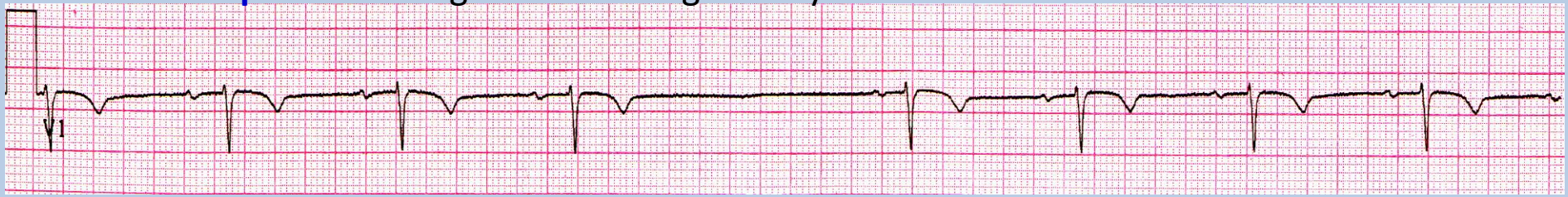
Regular – AV node re-entry tachycardia

Irregular – pattern: Group beating – ventricular bigeminy

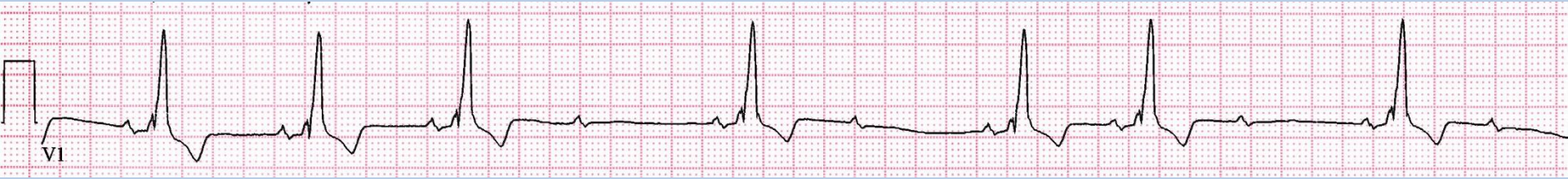
Irregular – pattern: Group beating – 4:3 Wenckebach AV block

Regularity

Intermittent pauses during otherwise regular rhythm – sino-atrial exit block



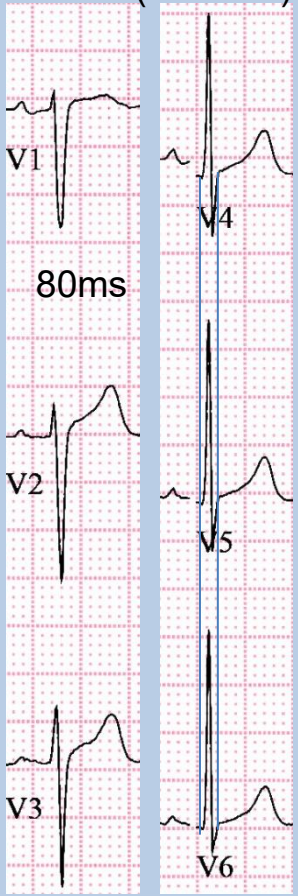
Intermittent pauses (non-conducted Ps) during otherwise regular rhythm – Mobitz II AV block



Random irregularity – due to atrial fibrillation

QRS width

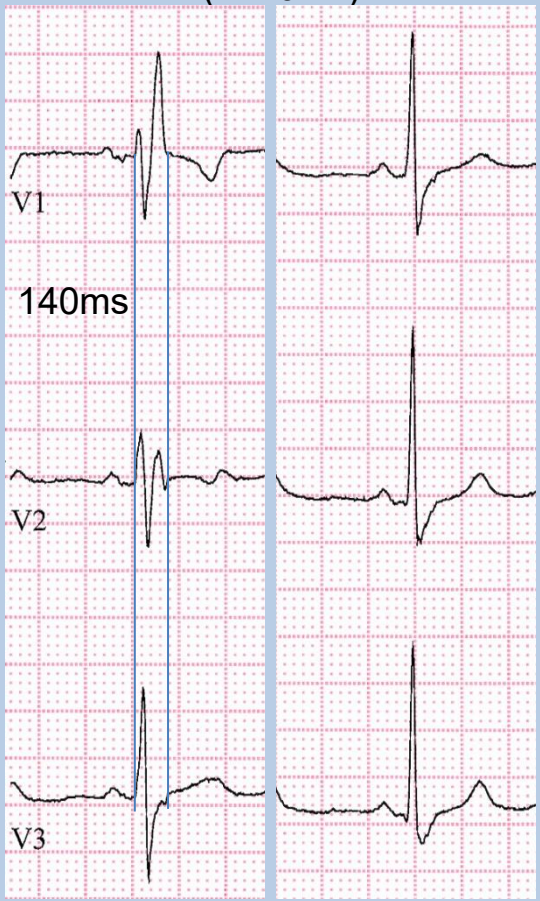
Normal (≤100ms)



Best measured in the chest leads

Use simultaneous leads to check the beginning and end of the QRS, where possible

Wide (≥120ms)



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

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

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Incorrect lead placement

Left-right arm leads reversed

Leads correct

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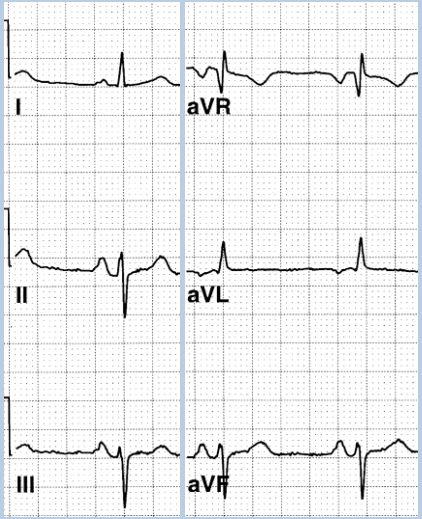
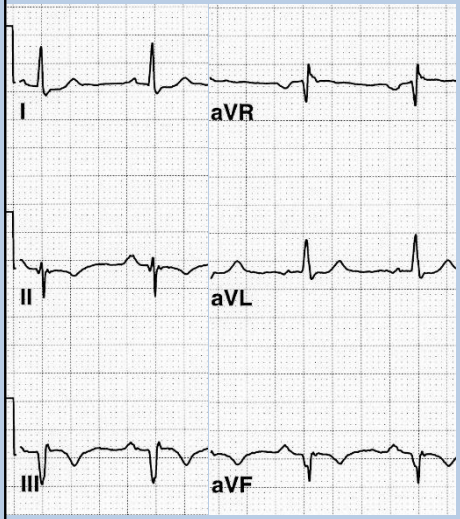
Left axis deviation

Left anterior fascicular block



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

Wolff-Parkinson-White pattern

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

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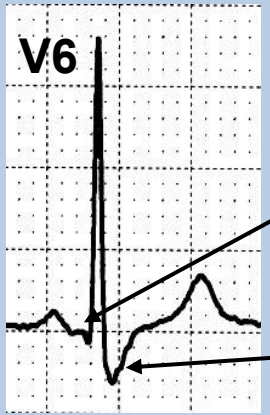
Typical patterns of right & left bundle branch block

RBBB

V1 & V2 positive
rSR' in V1

Broad *terminal* R in V1

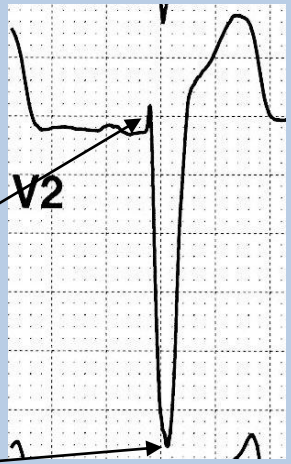


Normal left ventricular activation (septal q, rapid R upstroke in V6)

Small, broad terminal s in V6

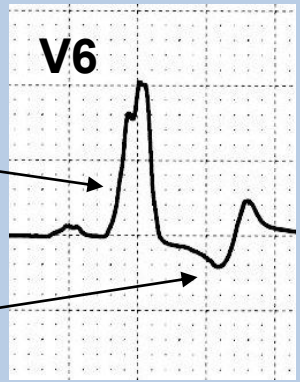
LBBB

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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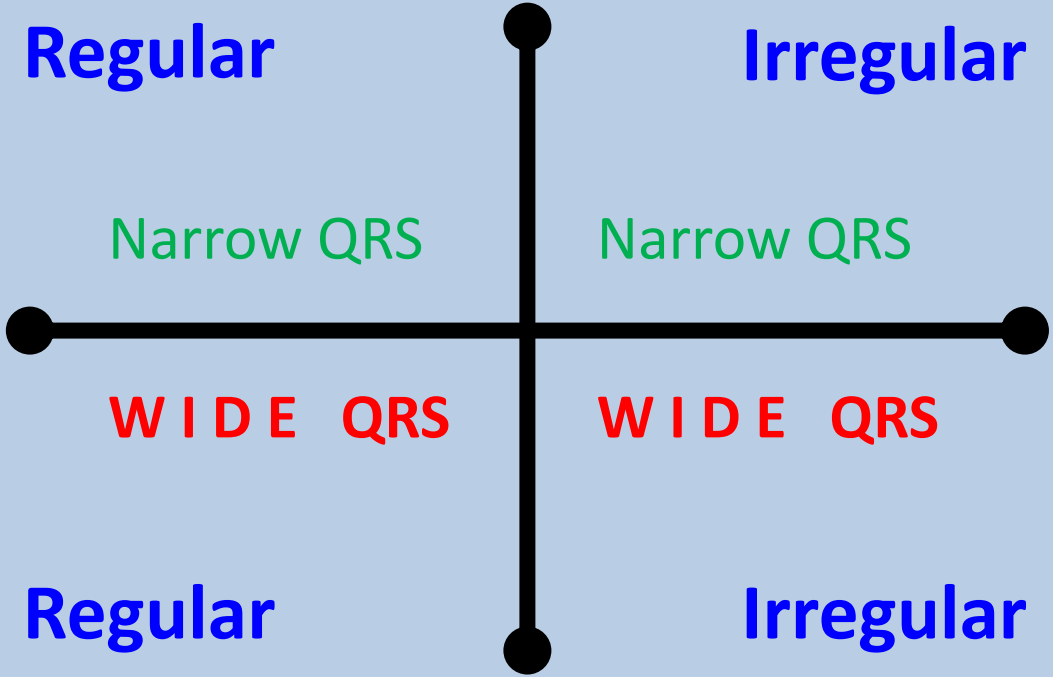
TACHYARRHYTHMIAS



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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

Regular

WIDE QRS

- **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

Irregular

WIDE QRS

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

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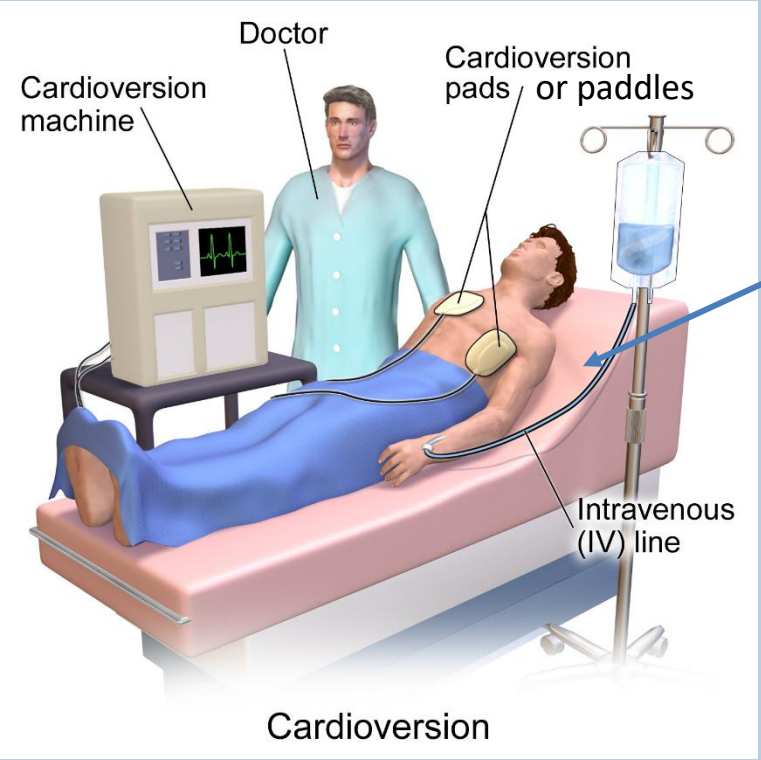
Synchronised DC cardioversion



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 leads)
- Recheck synchronisation
- Deliver shock
- Check ECG rhythm and vital signs
- Do 12 lead ECG

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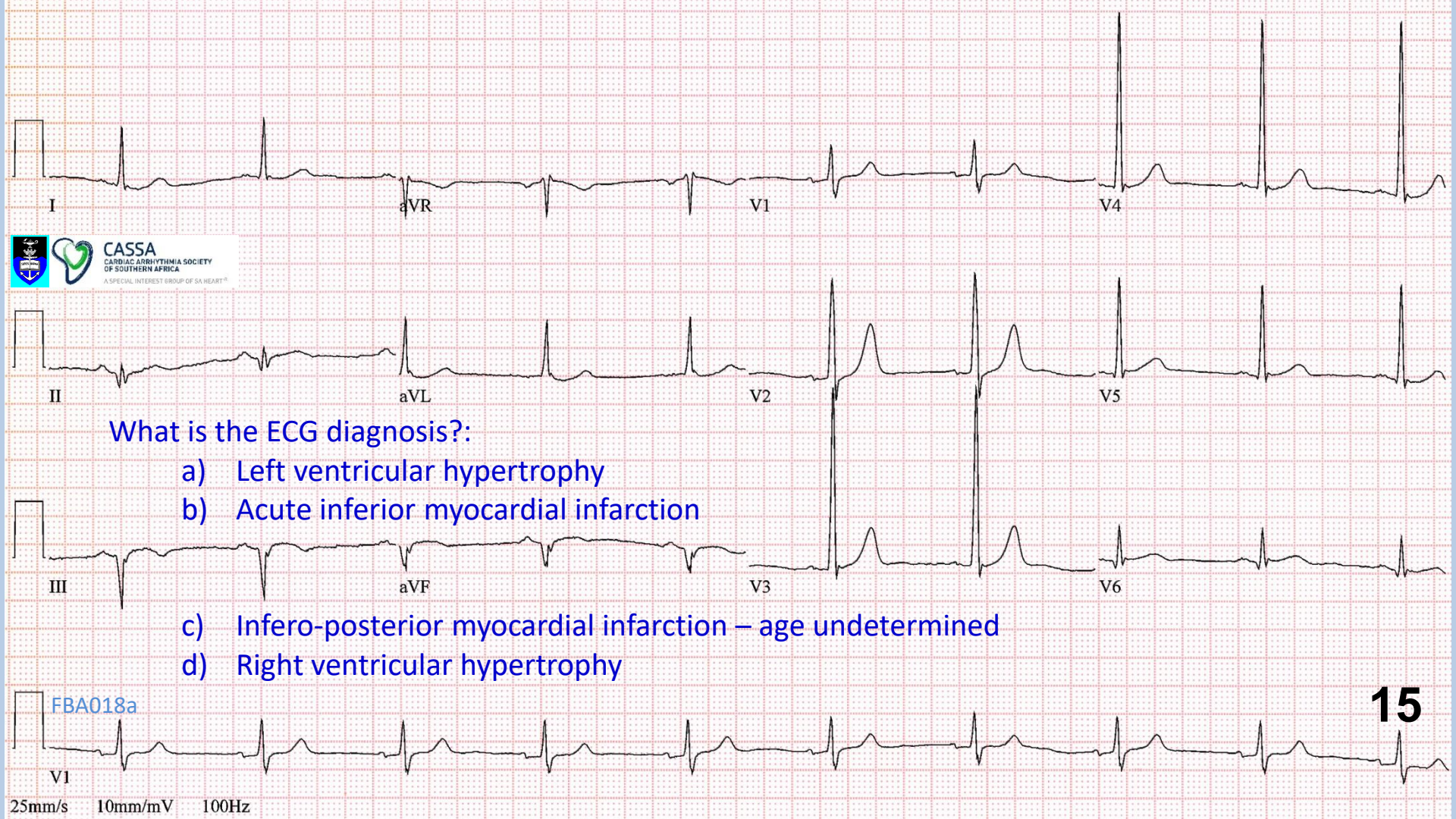

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What is the ECG diagnosis?:

a) Left ventricular hypertrophy
b) Acute inferior myocardial infarction
c) Infero-posterior myocardial infarction – age undetermined
d) Right ventricular hypertrophy

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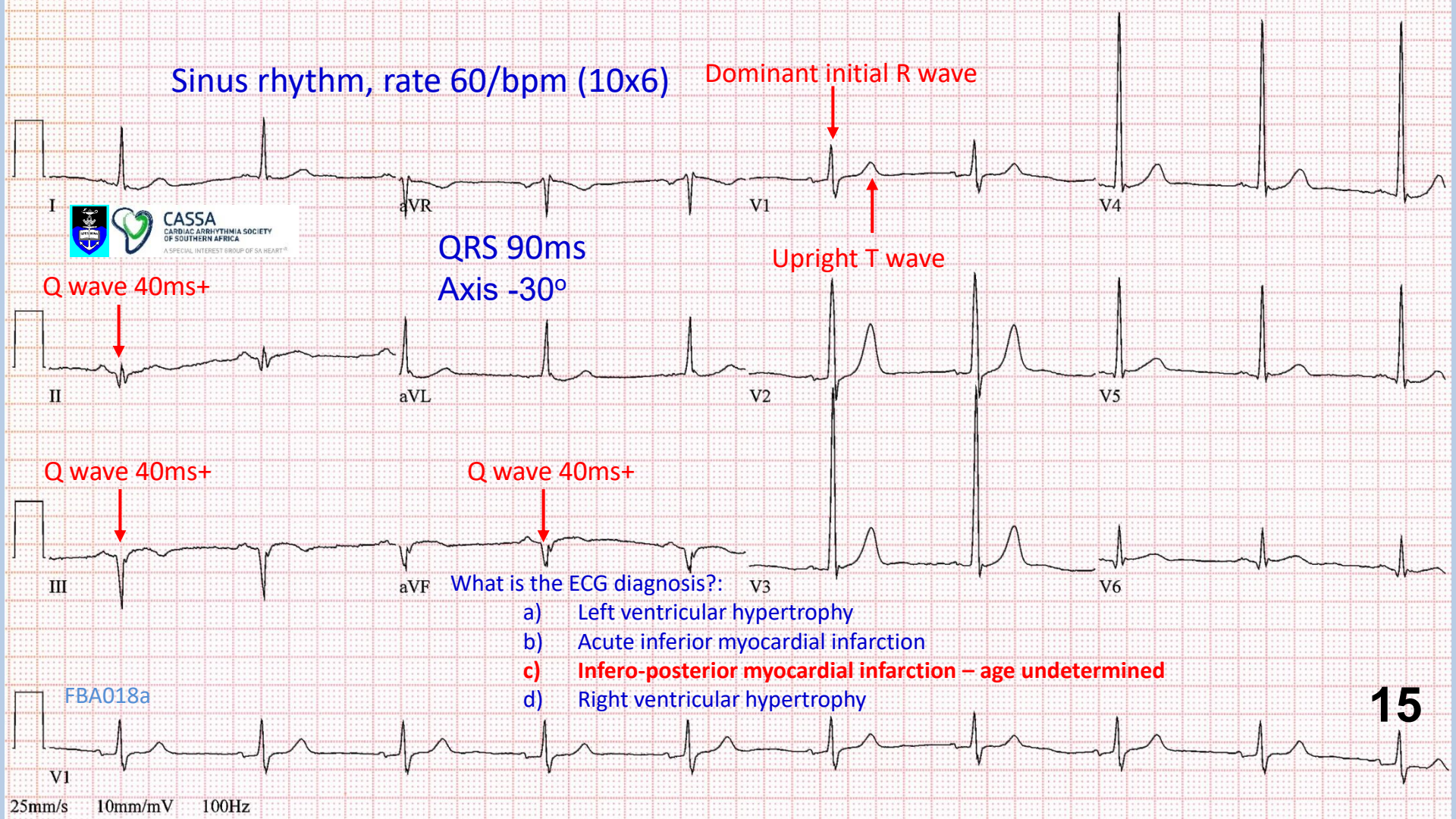
Sinus rhythm, rate 60/bpm (10x6)
Dominant initial R wave
I
aVR
V1
V4
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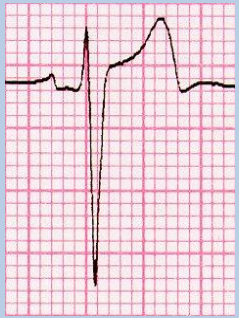
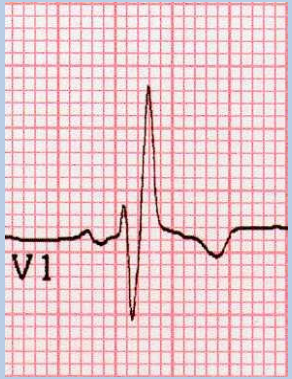
QRS 90ms
Axis -30°
Upright T wave
Q wave 40ms+
II
aVL
V2
V5
Q wave 40ms+
Q wave 40ms+
III
aVF
V3
V6
What is the ECG diagnosis?:
a) Left ventricular hypertrophy
b) Acute inferior myocardial infarction
c) Infero-posterior myocardial infarction – age undetermined
d) Right ventricular hypertrophy
FBA018a
15
V1
25mm/s 10mm/mV 100Hz

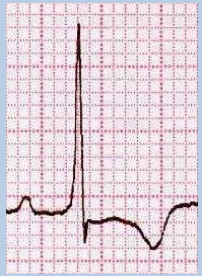
Dominant R wave in V1



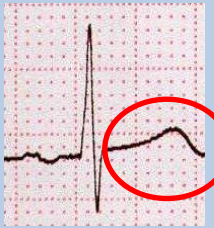
Normal



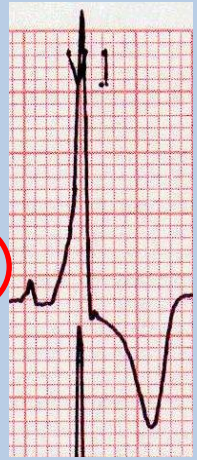
RBBB



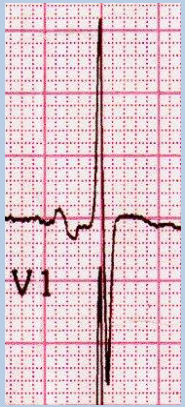
RVH



Posterior MI



WPW



Duchenne's

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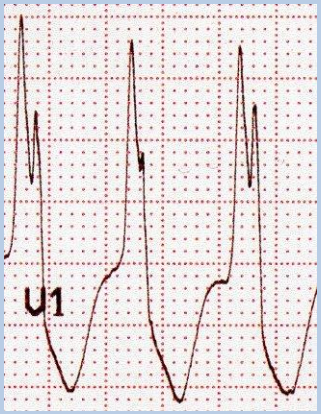
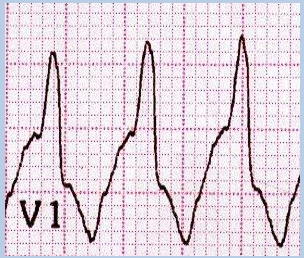
Anterior MI - RBBB

ARVC

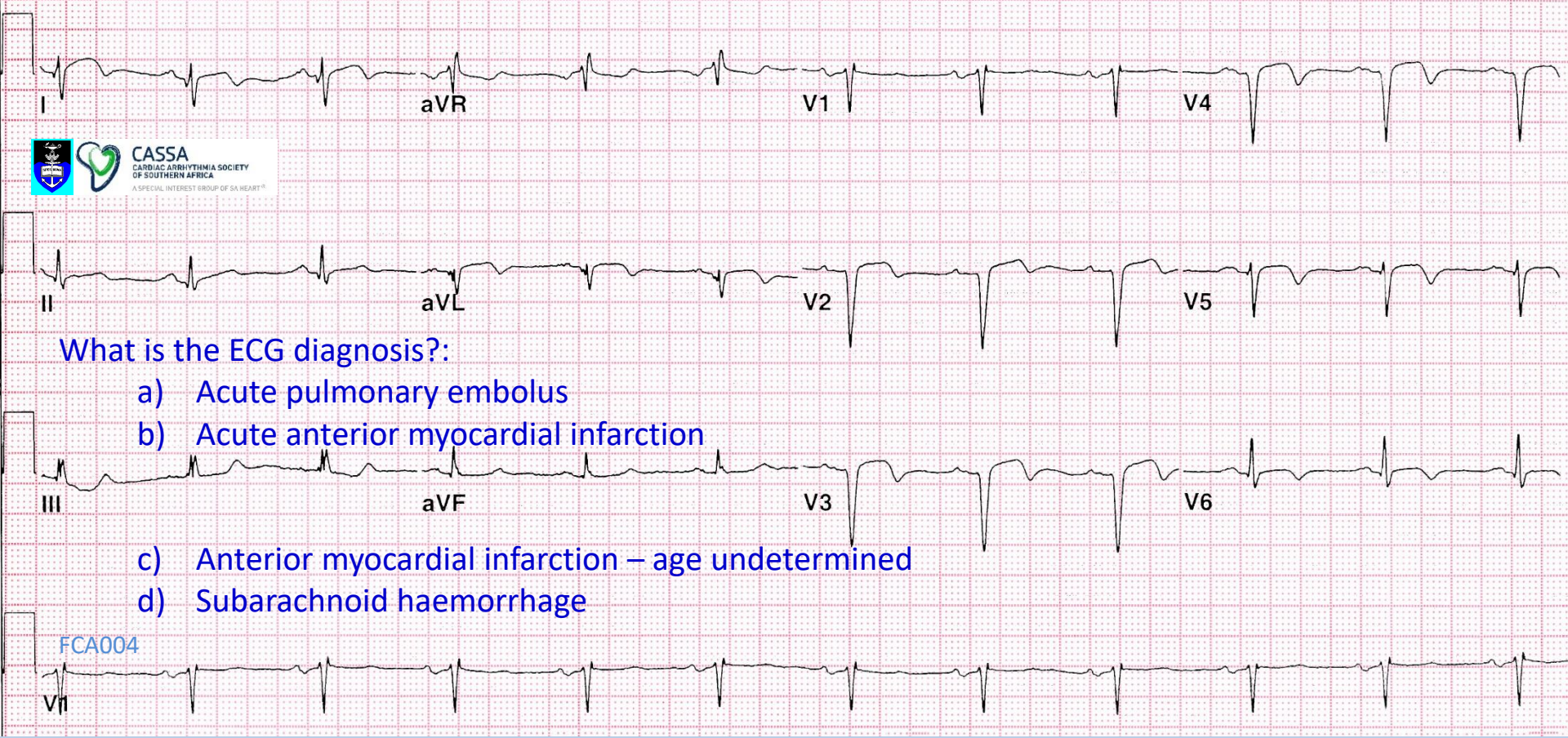


Ventricular rhythms



Antidromic tachycardia - WPW

LV pacing



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What is the ECG diagnosis?:

a) Acute pulmonary embolus
b) Acute anterior myocardial infarction
c) Anterior myocardial infarction – age undetermined
d) Subarachnoid haemorrhage

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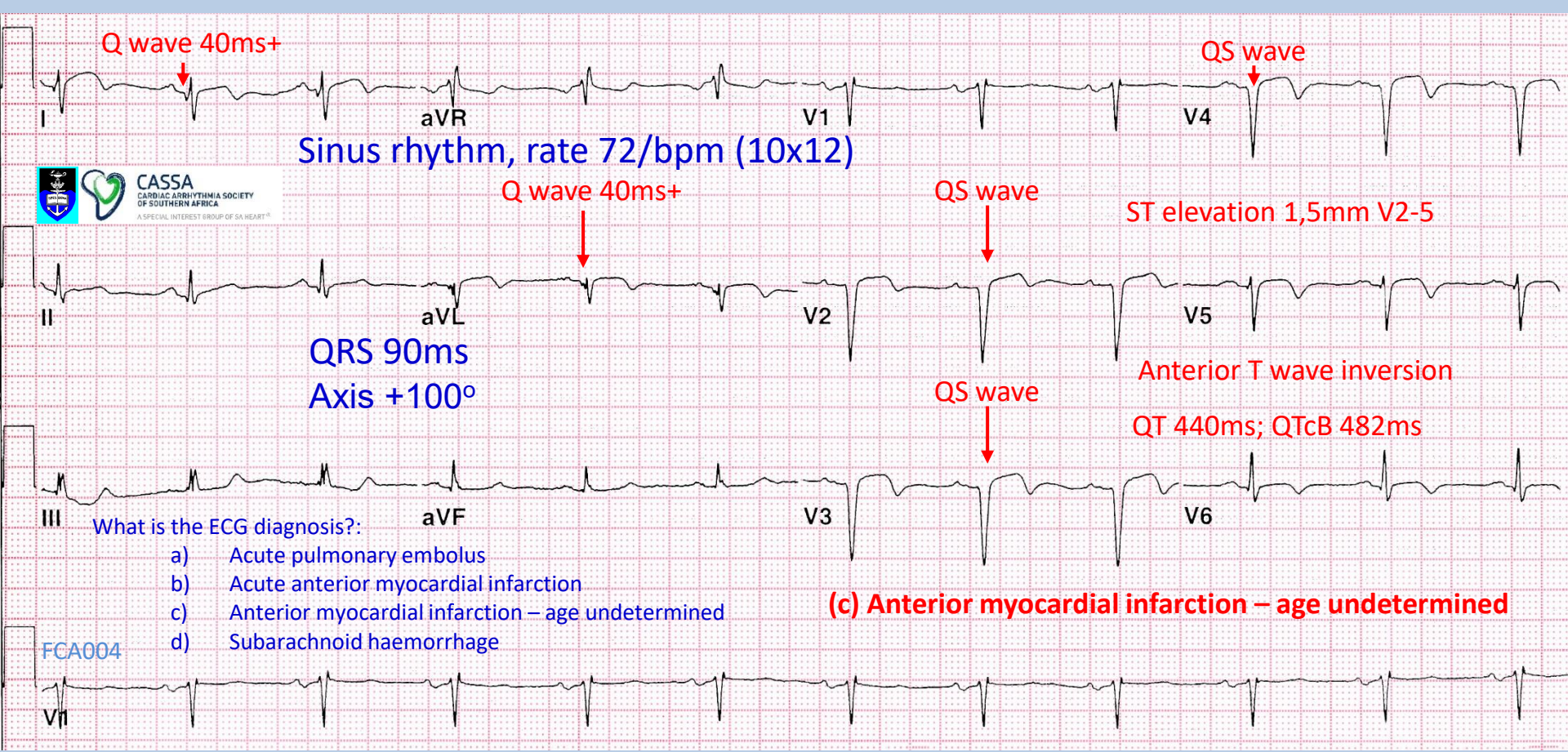
Q wave 40ms+
I
aVR
V1
V4
QS wave
Sinus rhythm, rate 72/bpm (10x12)
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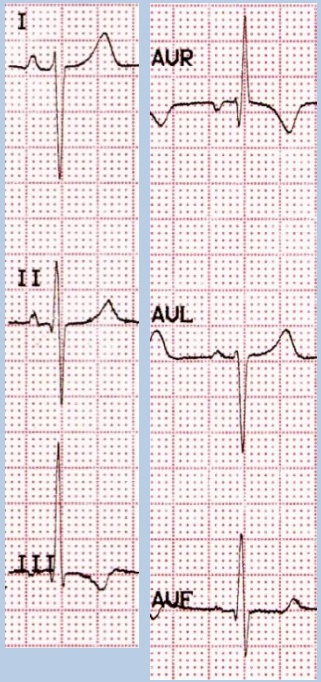
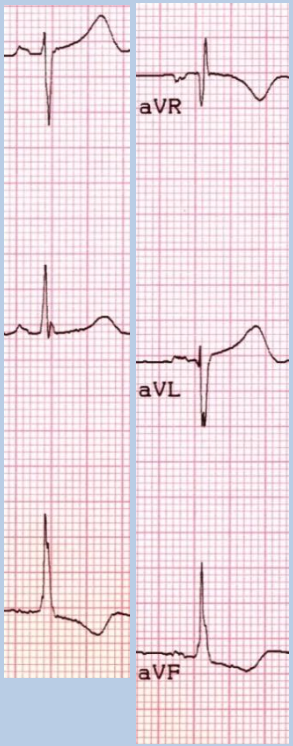
Q wave 40ms+
QS wave
ST elevation 1,5mm V2-5
II
aVL
V2
V5
QRS 90ms
Axis +100°
Anterior T wave inversion
QS wave
QT 440ms; QTcB 482ms
III
aVF
V3
V6
What is the ECG diagnosis?:
a) Acute pulmonary embolus
b) Acute anterior myocardial infarction
c) Anterior myocardial infarction – age undetermined
d) Subarachnoid haemorrhage
(c) Anterior myocardial infarction – age undetermined
FCA004
VI

Mechanisms of right axis deviation

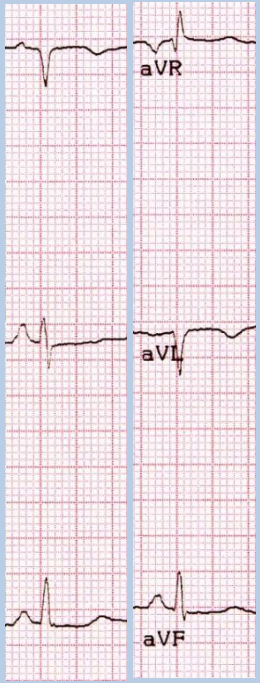
RVH



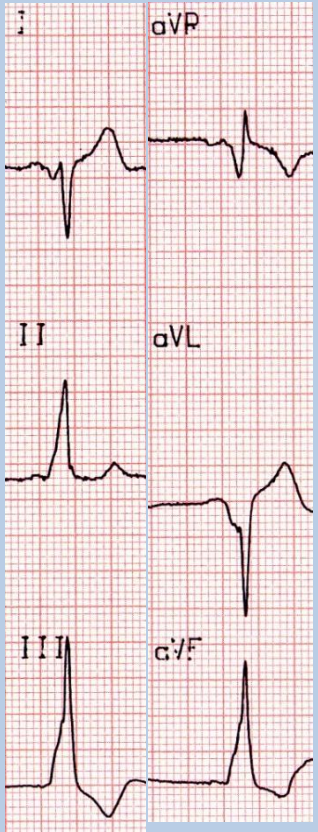
L posterior fascicular block



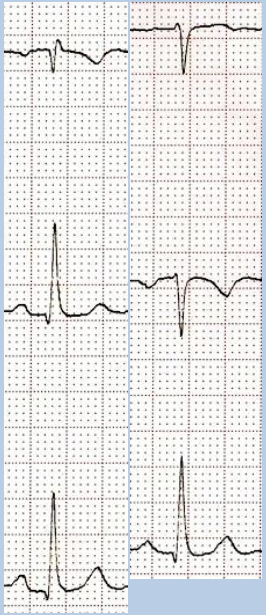
Lateral myocardial infarction



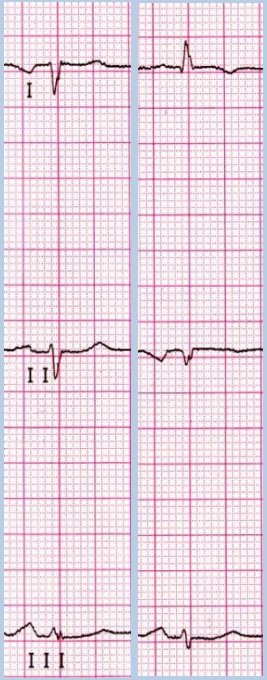
WPW pattern



Limb leads misplaced



Mirror-image dextrocardia



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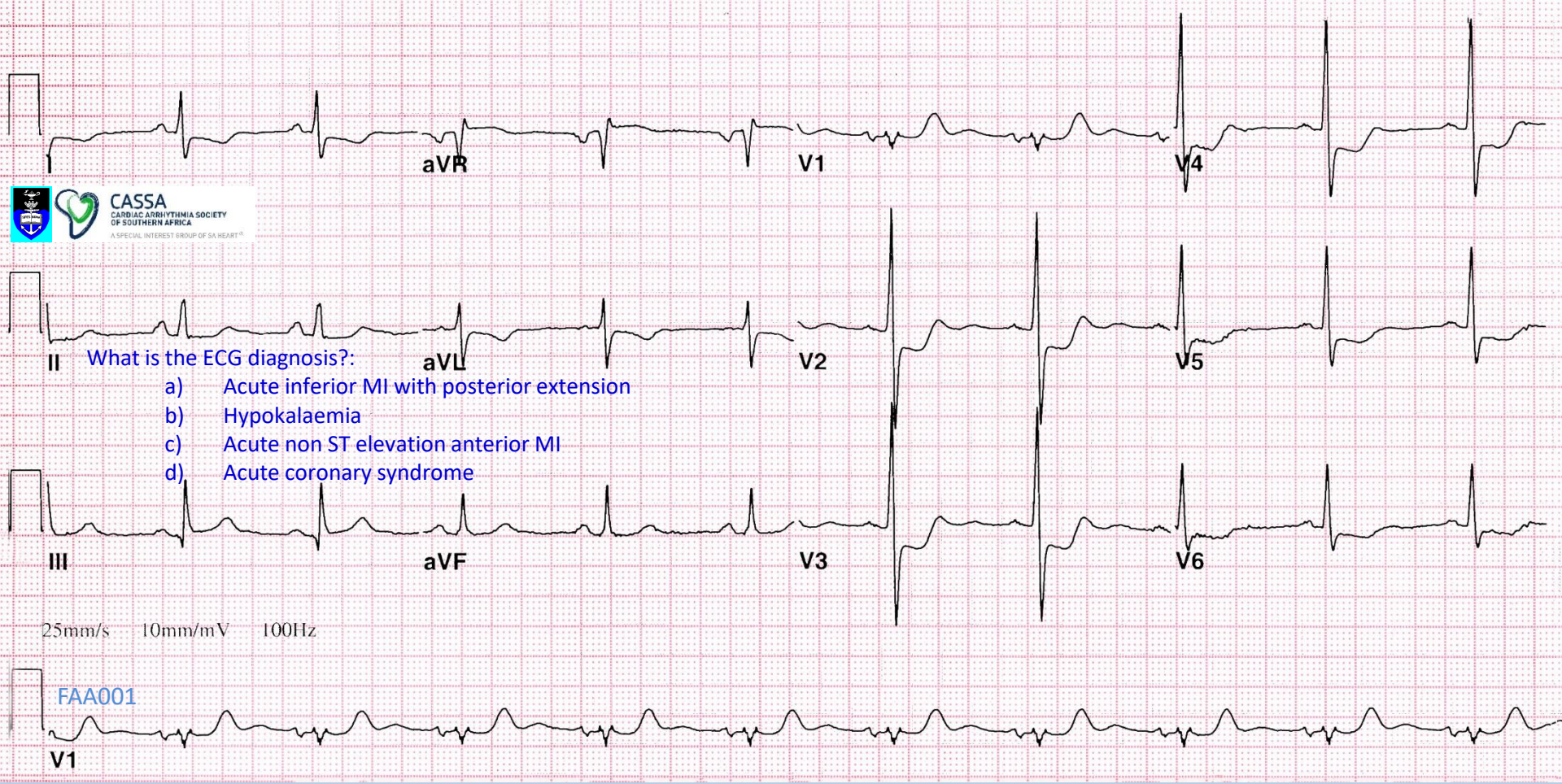

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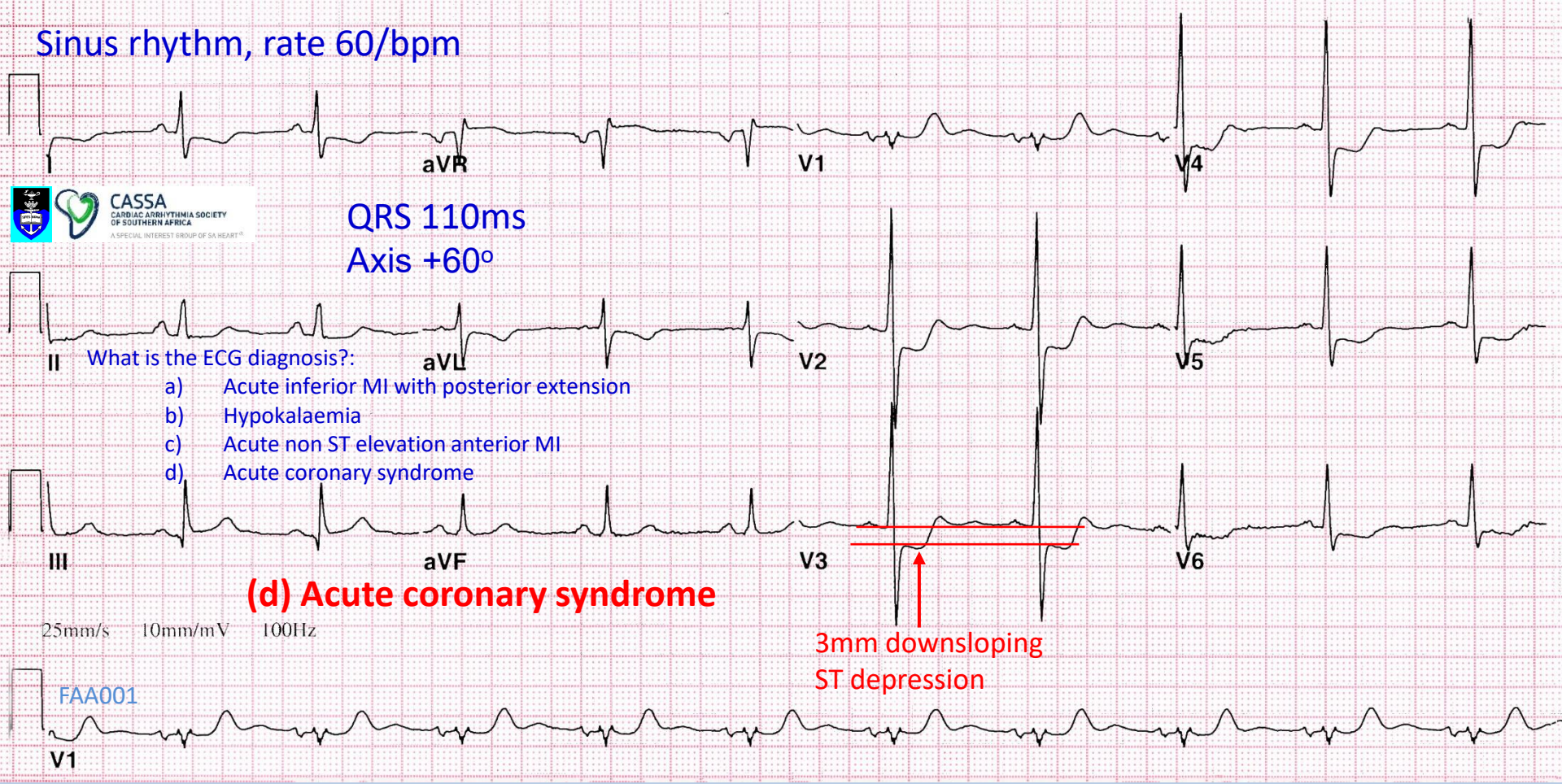
What is the ECG diagnosis?:

a) Acute inferior MI with posterior extension
b) Hypokalaemia
c) Acute non ST elevation anterior MI
d) Acute coronary syndrome


Sinus rhythm, rate 60/bpm
I
aVR
V1
V4
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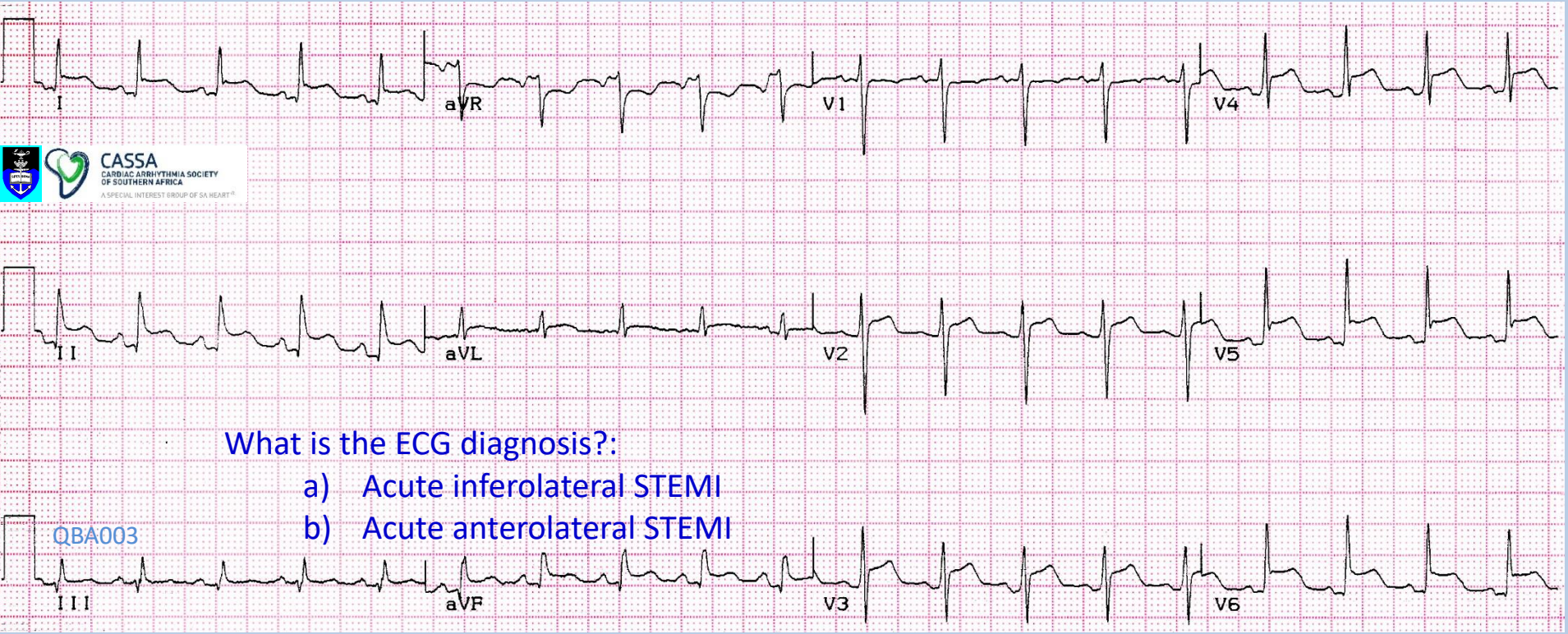
QRS 110ms
Axis +60o
II
aVL
V2
V5
What is the ECG diagnosis?:
a) Acute inferior MI with posterior extension
b) Hypokalaemia
c) Acute non ST elevation anterior MI
d) Acute coronary syndrome
III
aVF
V3
V6
(d) Acute coronary syndrome
25mm/s 10mm/mV 100Hz
3mm downsloping
ST depression
FAA001
V1



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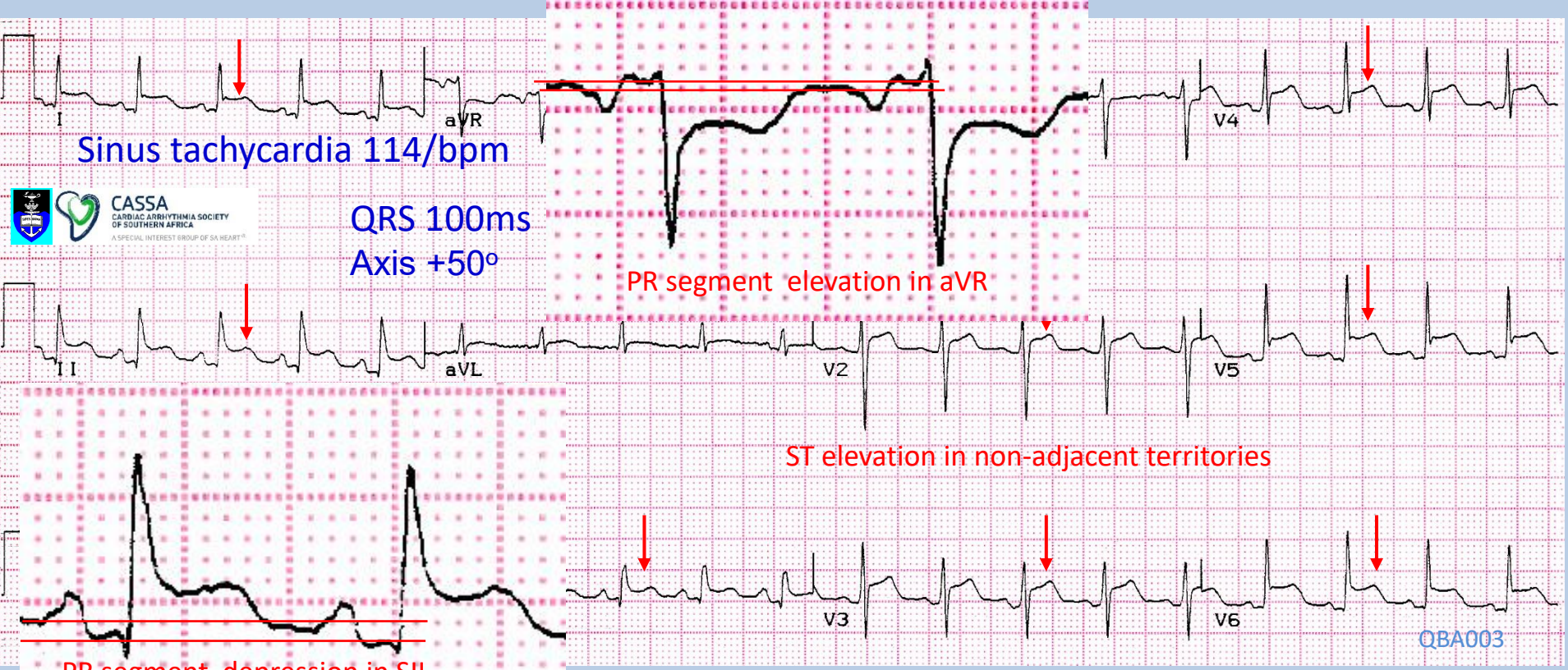
What is the ECG diagnosis?:

a) Acute inferolateral STEMI
b) Acute anterolateral STEMI

QBA003

c) Acute pericarditis
d) Early repolarisation syndrome



Sinus tachycardia 114/bpm

QRS 100ms

Axis +50°

PR segment elevation in aVR

ST elevation in non-adjacent territories

PR segment depression in SII

What is the ECG diagnosis?:

a) Acute inferolateral STEMI
b) Acute anterolateral STEMI
c) Acute pericarditis
d) Early repolarisation syndrome

(c) Acute pericarditis

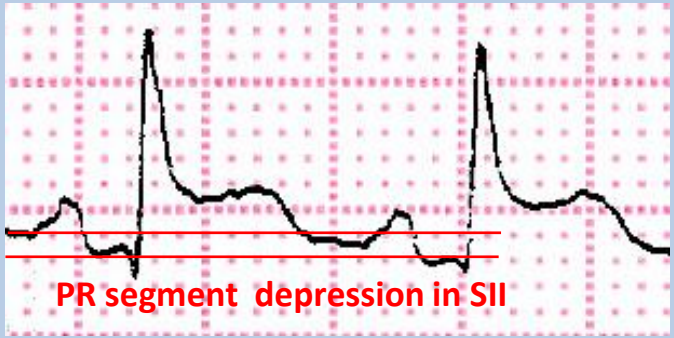
Acute pericarditis vs STEMI

Clinical:

- Chest pain can be similar, but pericarditis is characteristically sharper and worse on breathing or swallowing. It is less severe on sitting forward.
- Pericarditis may accompany other systemic illness
- Pericarditis may complicate acute myocardial infarction
- A pericardial friction rub may be heard

ECG:

- ST elevation tends to be widespread in pericarditis
- STEMI: ST elevation in adjacent leads only
- PR segment elevation in aVR and depression in II is diagnostic of pericarditis



PR segment depression in SII

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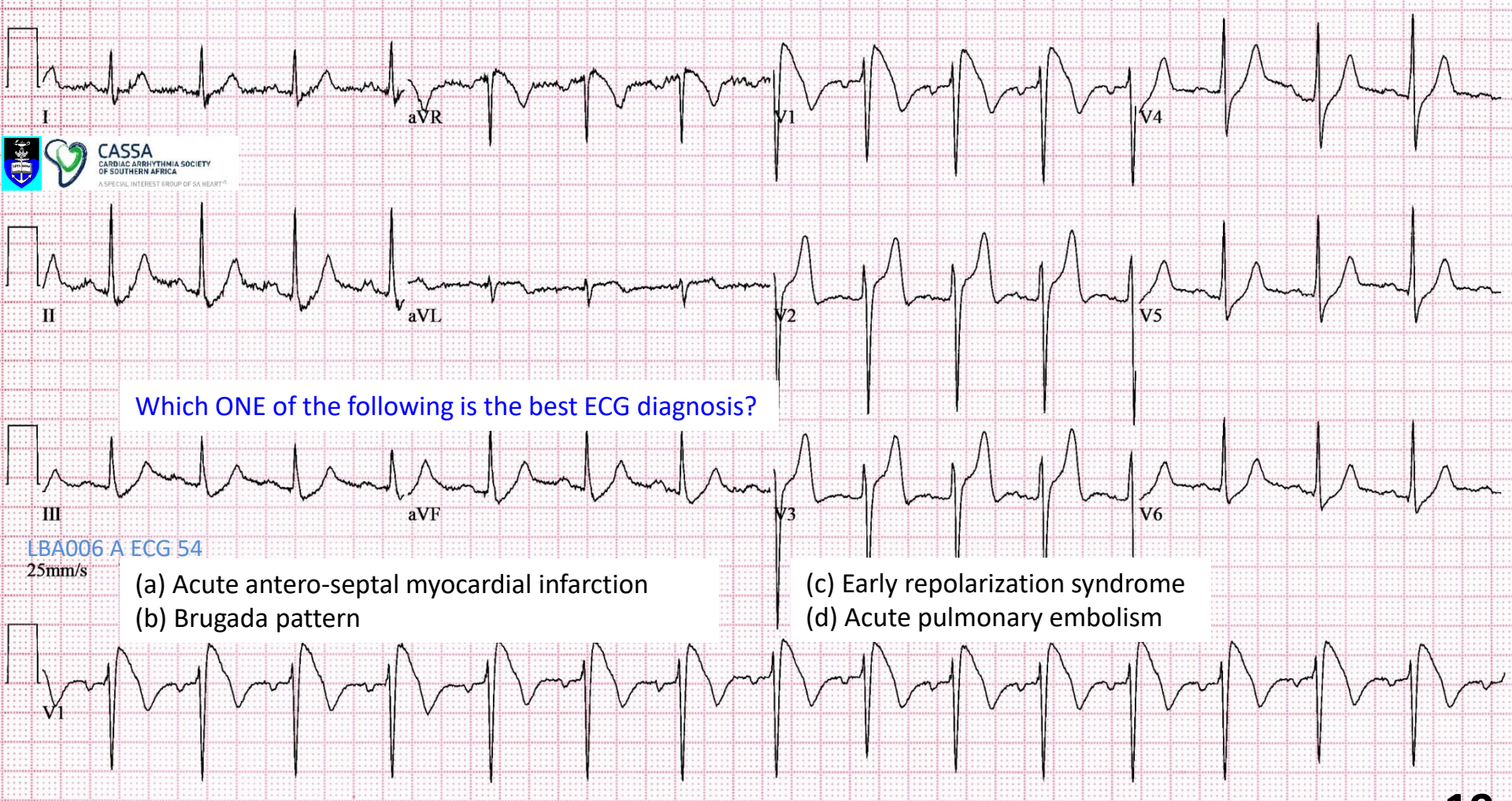
PR segment elevation in aVR



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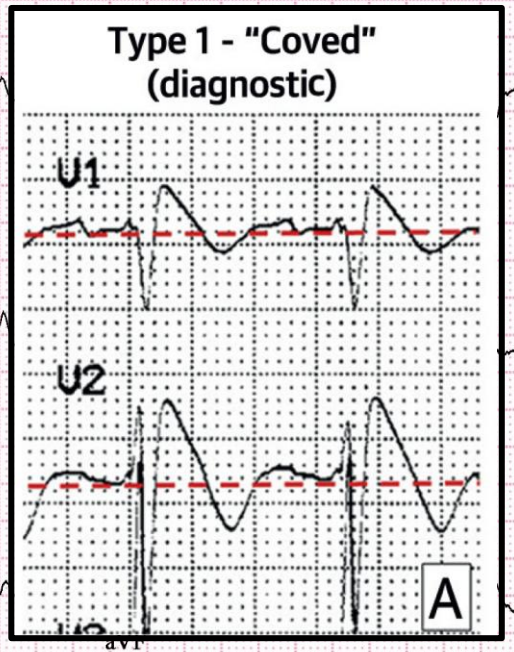
Which ONE of the following is the best ECG diagnosis?

LBA006 A ECG 54
25mm/s

(a) Acute antero-septal myocardial infarction
(b) Brugada pattern
(c) Early repolarization syndrome
(d) Acute pulmonary embolism



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LBA006 A ECG 54

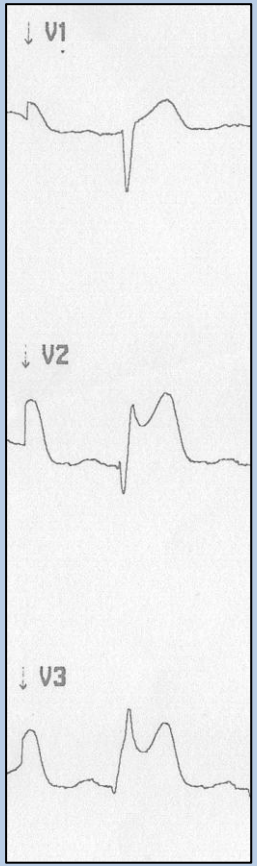
I II III V1 V2 V3 V4 V5 V6

25mm/s

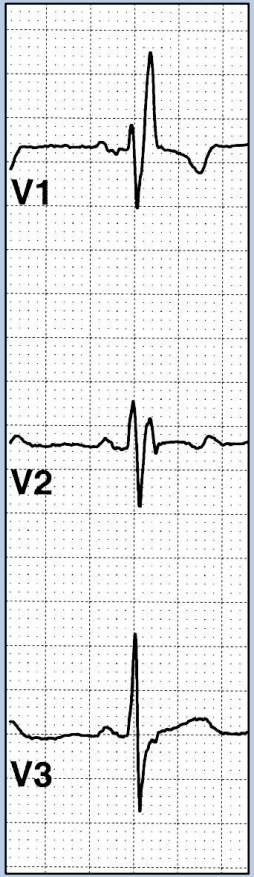
(a) Acute antero-septal myocardial infarction
(b) **Brugada pattern**

(c) Early repolarization syndrome
(d) Right bundle branch block

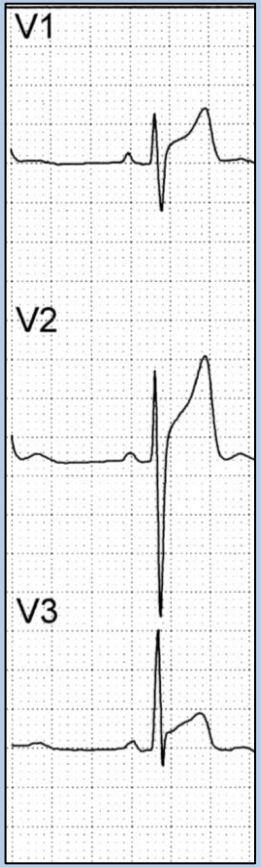
Brugada pattern



Acute STEMI



RBBB pattern



Early repolarization pattern

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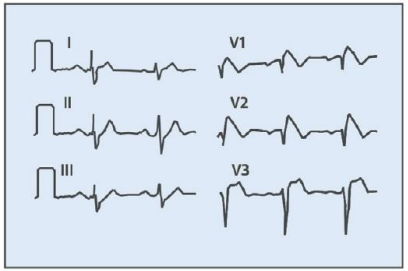
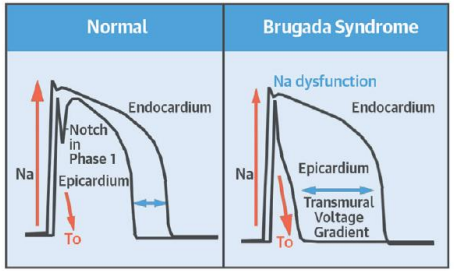
CENTRAL ILLUSTRATION Main Characteristics of Brugada Syndrome

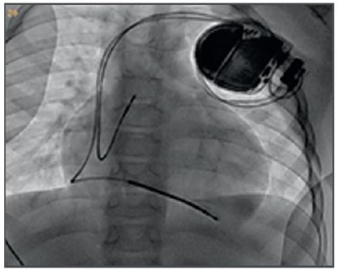
Brugada Syndrome



Coved type ST-segment in V1-V2

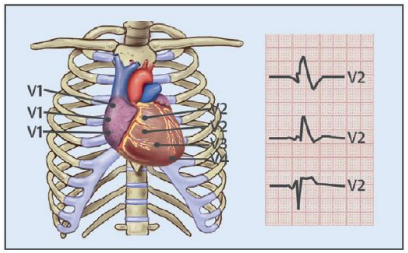


Loss of function of sodium channels

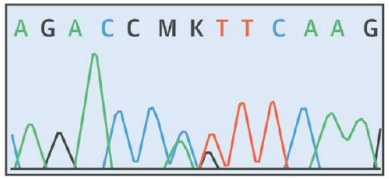


ICD is standard therapy, epicardial radiofrequency ablation a promising one

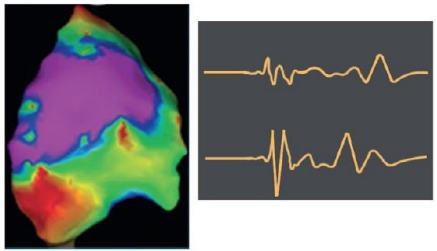
Diagnosis



Pathophysiology



Management



Brugada, J. et al. J Am Coll Cardiol. 2018;72(9):1046-59.

Knowledge about Brugada syndrome has grown over the last 30 years, from diagnostic criteria **(left)**, to pathophysiological mechanisms **(center)**, and finally, to management options **(right)**. ICD = implantable cardioverter-defibrillator.

BrugadaDrugs.org

Drugs to avoid

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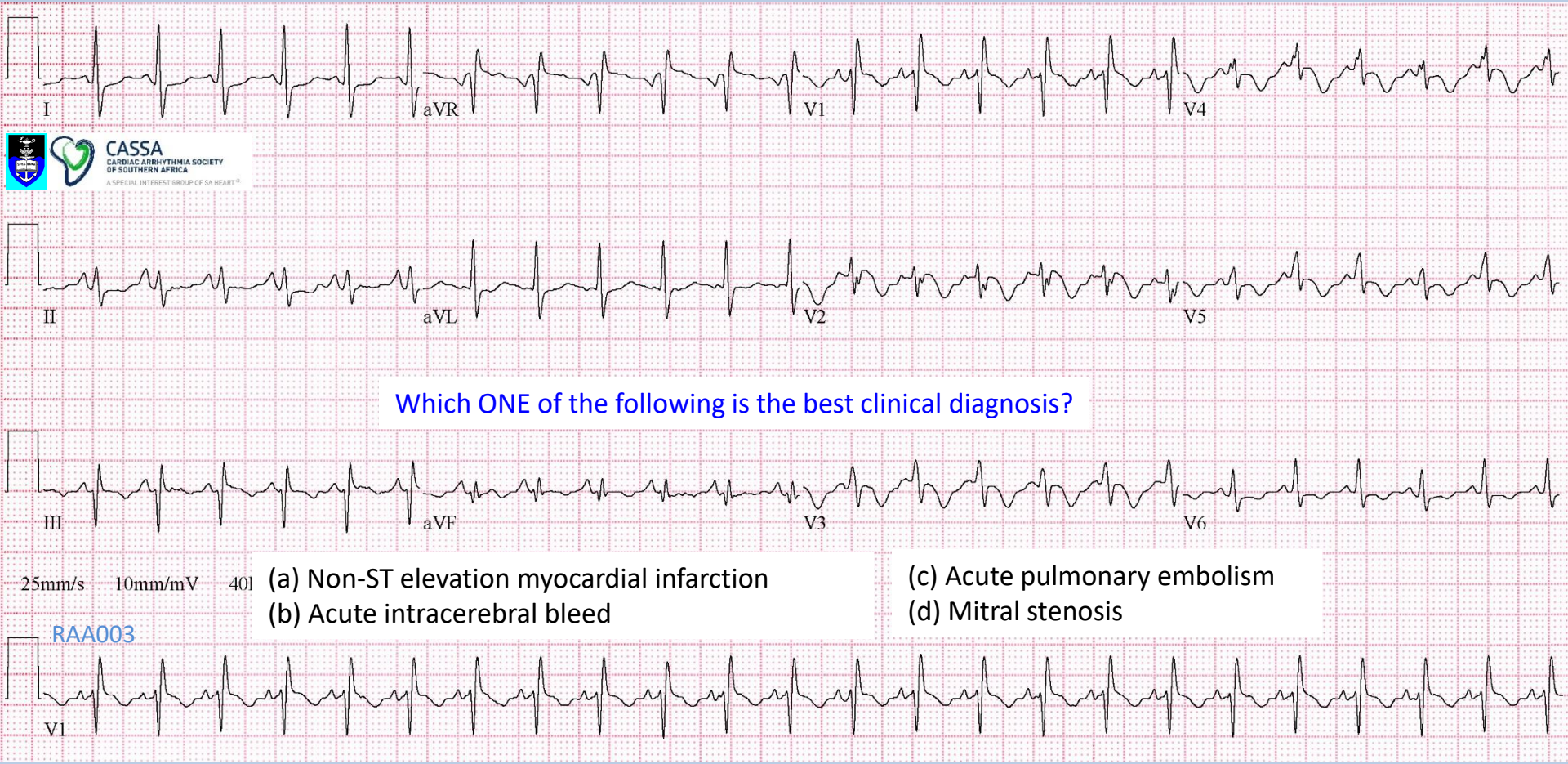

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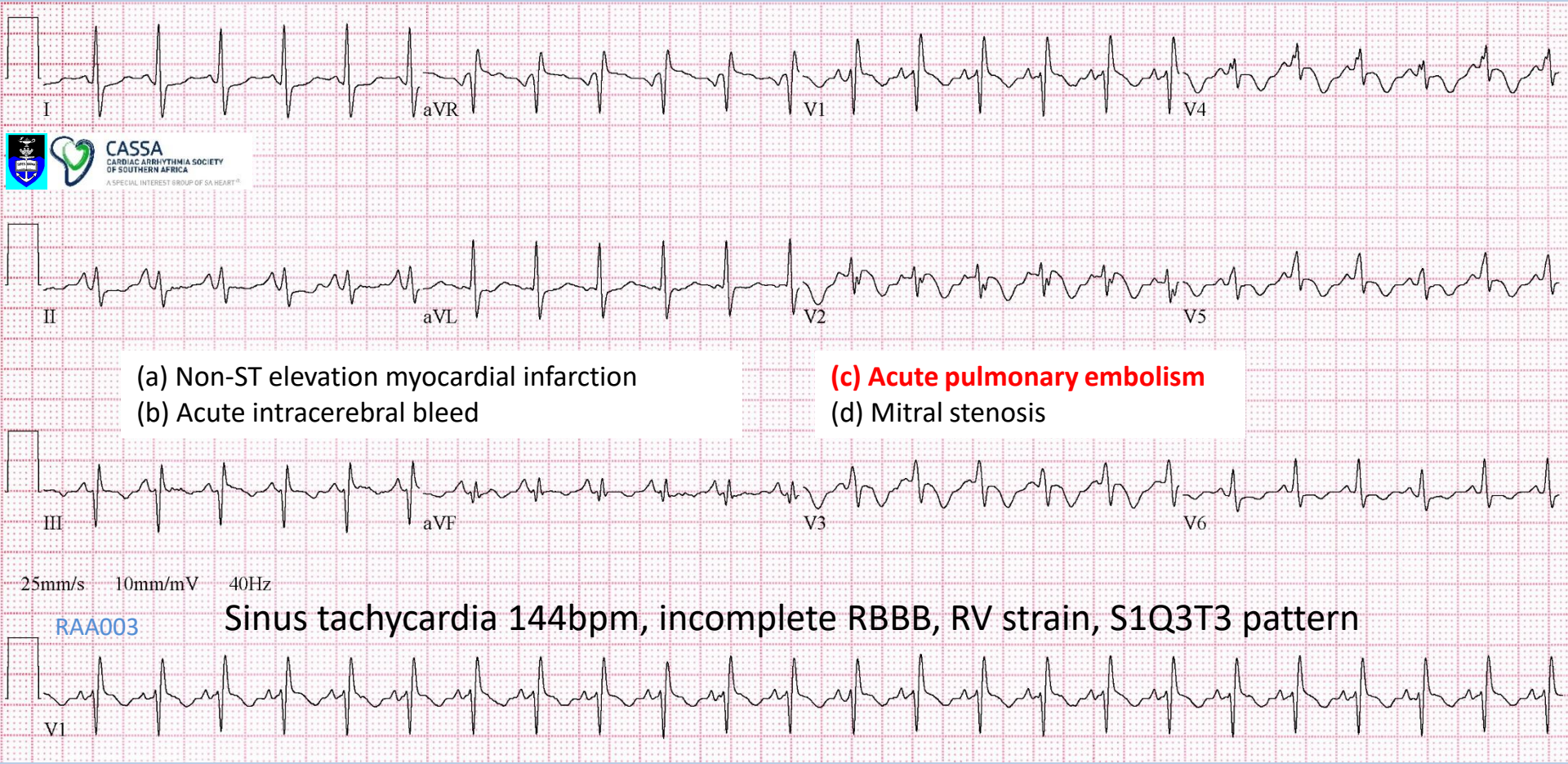
Which ONE of the following is the best clinical diagnosis?

(a) Non-ST elevation myocardial infarction
(b) Acute intracerebral bleed
(c) Acute pulmonary embolism
(d) Mitral stenosis



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(a) Non-ST elevation myocardial infarction
(b) Acute intracerebral bleed

(c) Acute pulmonary embolism
(d) Mitral stenosis

Sinus tachycardia 144bpm, incomplete RBBB, RV strain, S1Q3T3 pattern

Pulmonary Embolism

Frequency of abnormal findings (n=189)

Normal ECG:	22.7%
Sinus tachycardia:	27.5%
Complete or incomplete RBBB:	9%
Right ventricular strain:	11%
Right axis deviation:	4%
P pulmonale:	0.5%
S1Q3T3:	4%
Clockwise rotation:	20%
Atrial tachyarrhythmias:	10%

RV strain pattern had the highest specificity to diagnose PE

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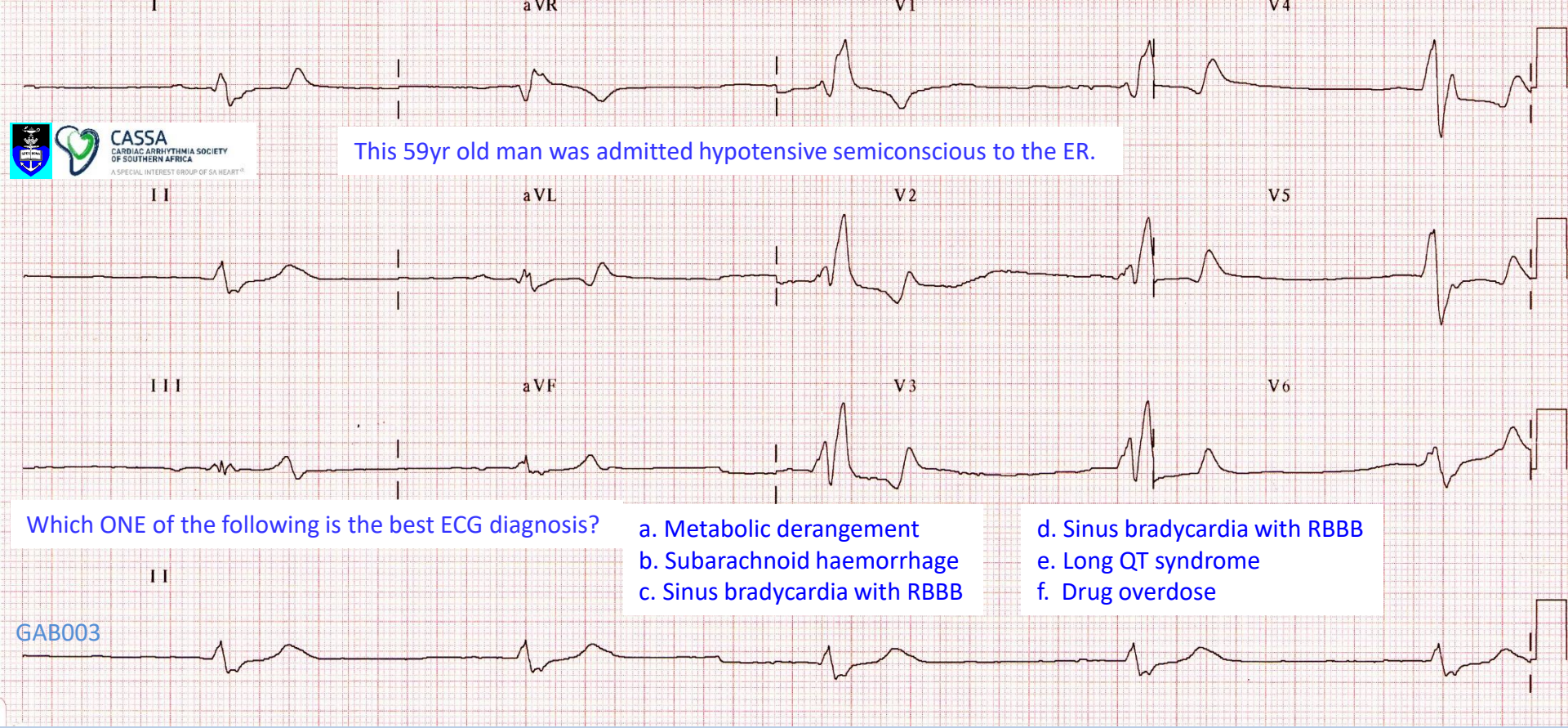
Thomson et al. , ECG in suspected PE, PMJ 2019



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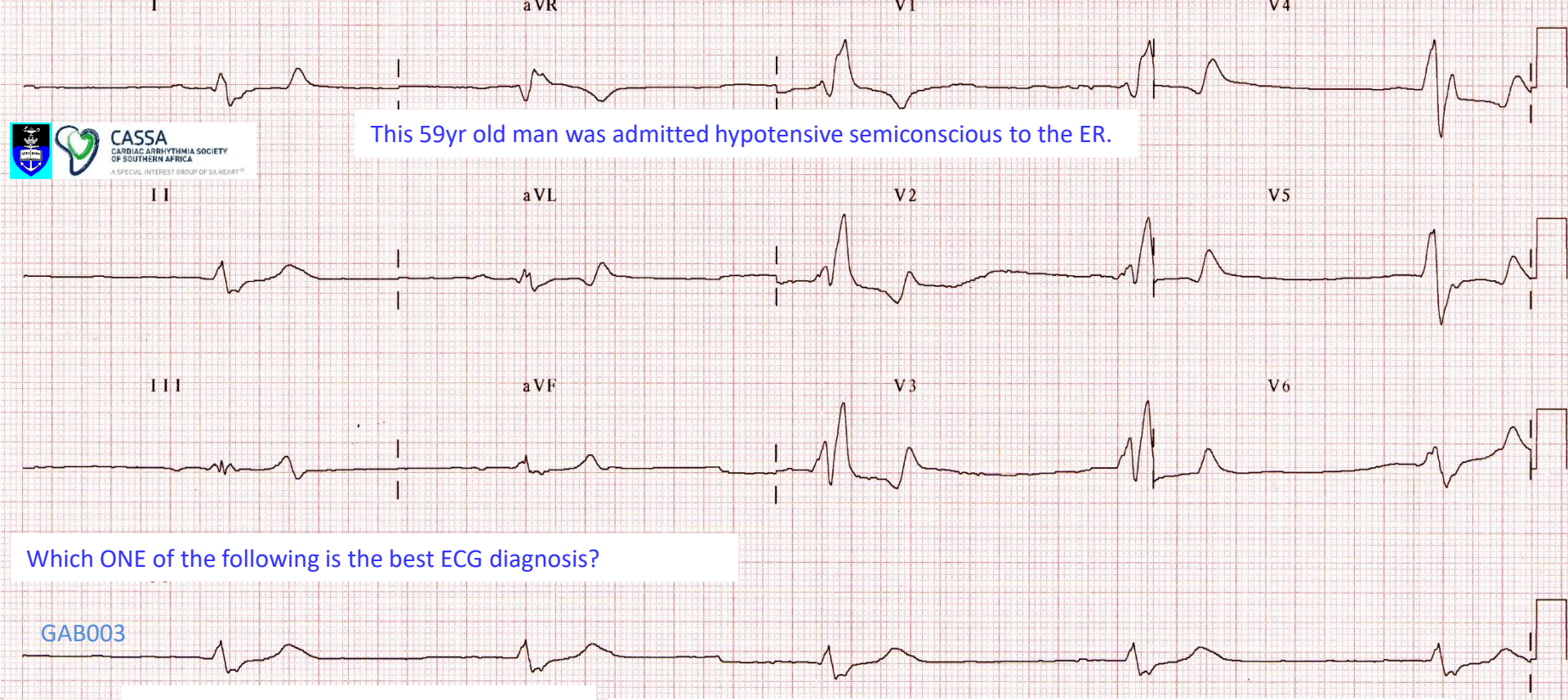
This 59yr old man was admitted hypotensive semiconscious to the ER.

Which ONE of the following is the best ECG diagnosis?

a. Metabolic derangement
b. Subarachnoid haemorrhage
c. Sinus bradycardia with RBBB
d. Sinus bradycardia with RBBB
e. Long QT syndrome
f. Drug overdose

GAB003



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GAB003

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c. Sinus bradycardia with RBBB
d. Long QT syndrome
e. Drug overdose

Blood chemistry: Na 143 **K^+ 8.8** Urea 97 Creat 1788

Hyperkalaemia

- T waves: symmetrical peaked (tented)
  - 1st ECG manifestation
  - Only in 22% pts
- P waves: ↓ amplitude, ↑ duration; flattening
- PR: prolongs
- QRS: widens; resembles RBBB / LBBB / nonspecific (but uniformly wide)
- R amplitude: ↓ amplitude
- S: becomes prominent
- ST segment: ↓; ↑ (pseudo-infarct)
- Ultimately: sine-wave rhythm; asystole or VF

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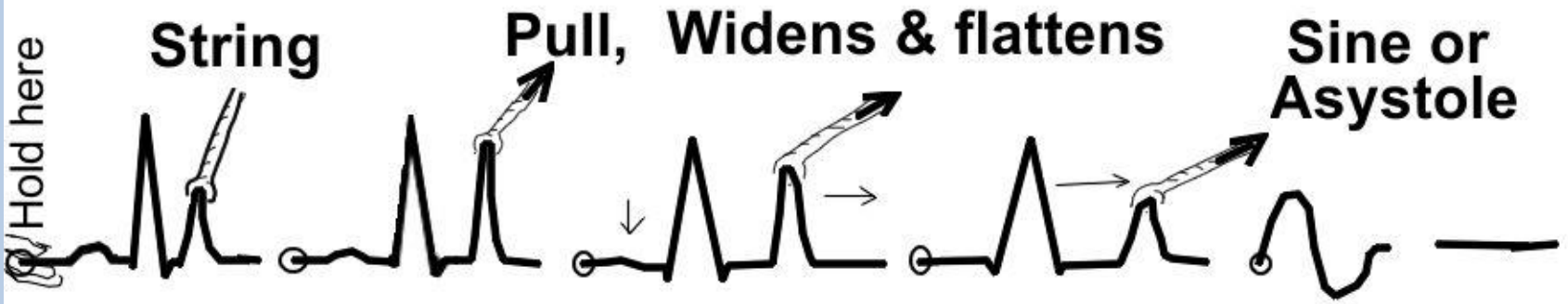
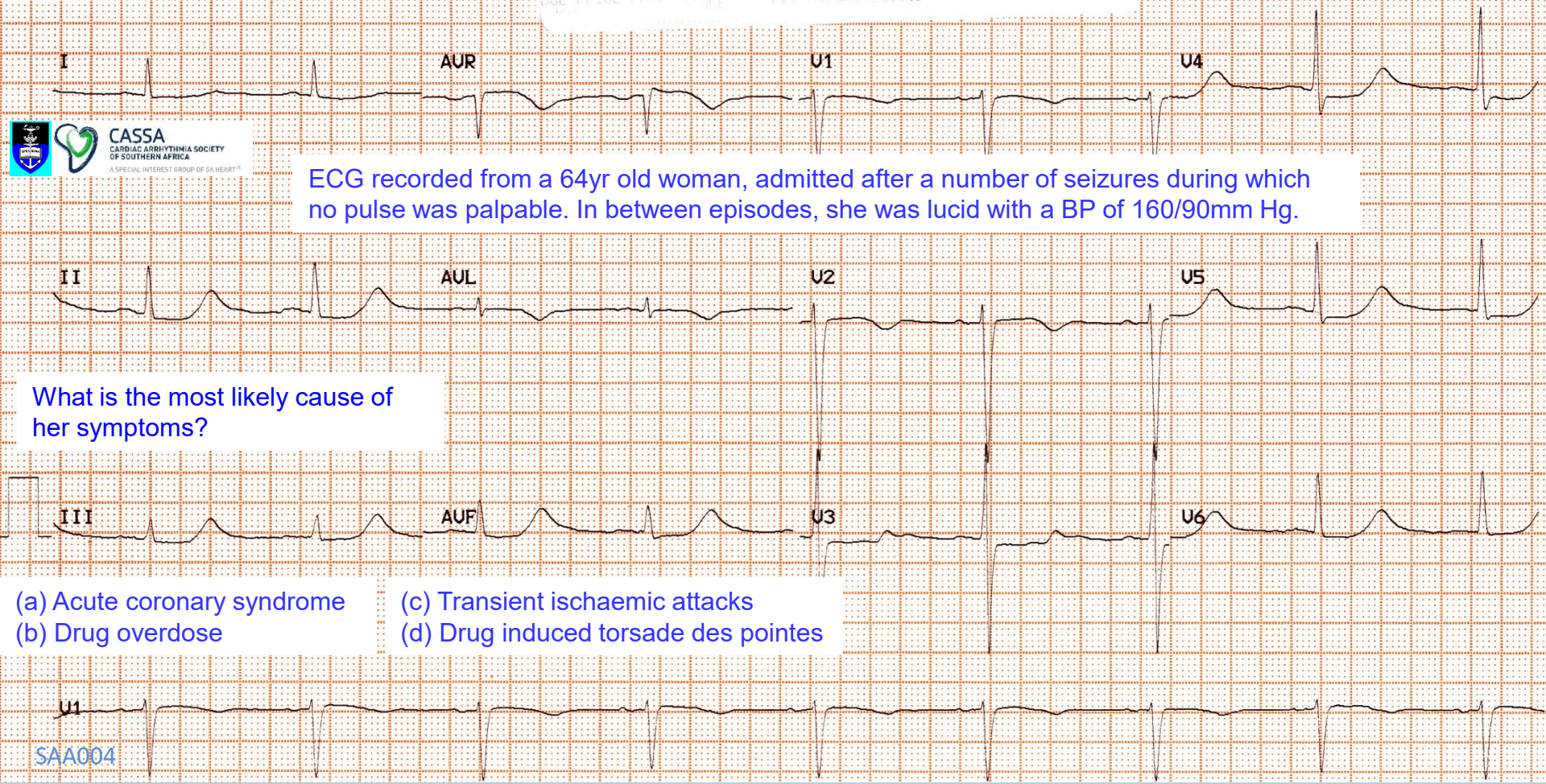
String Theory of Hyperkalemia





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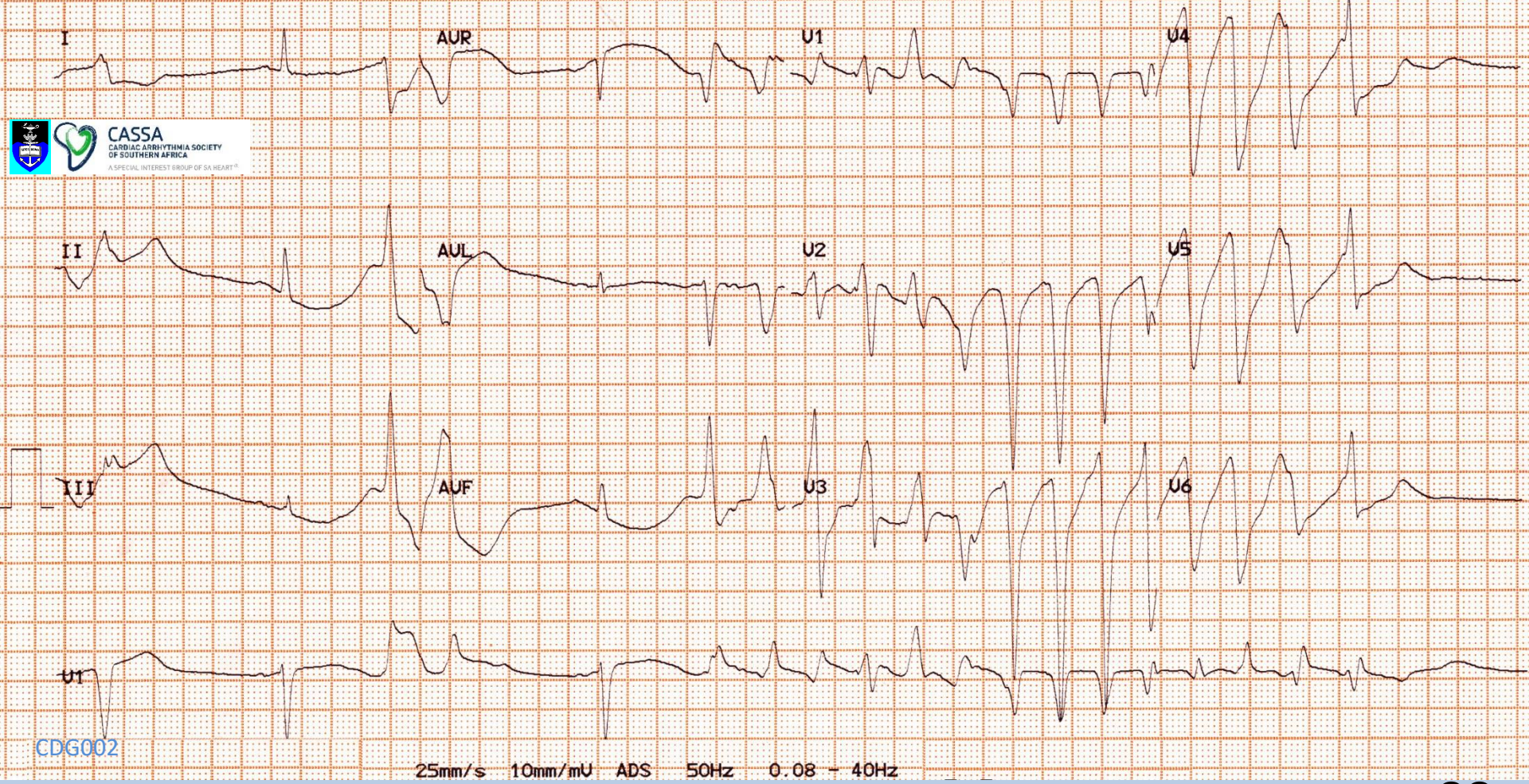
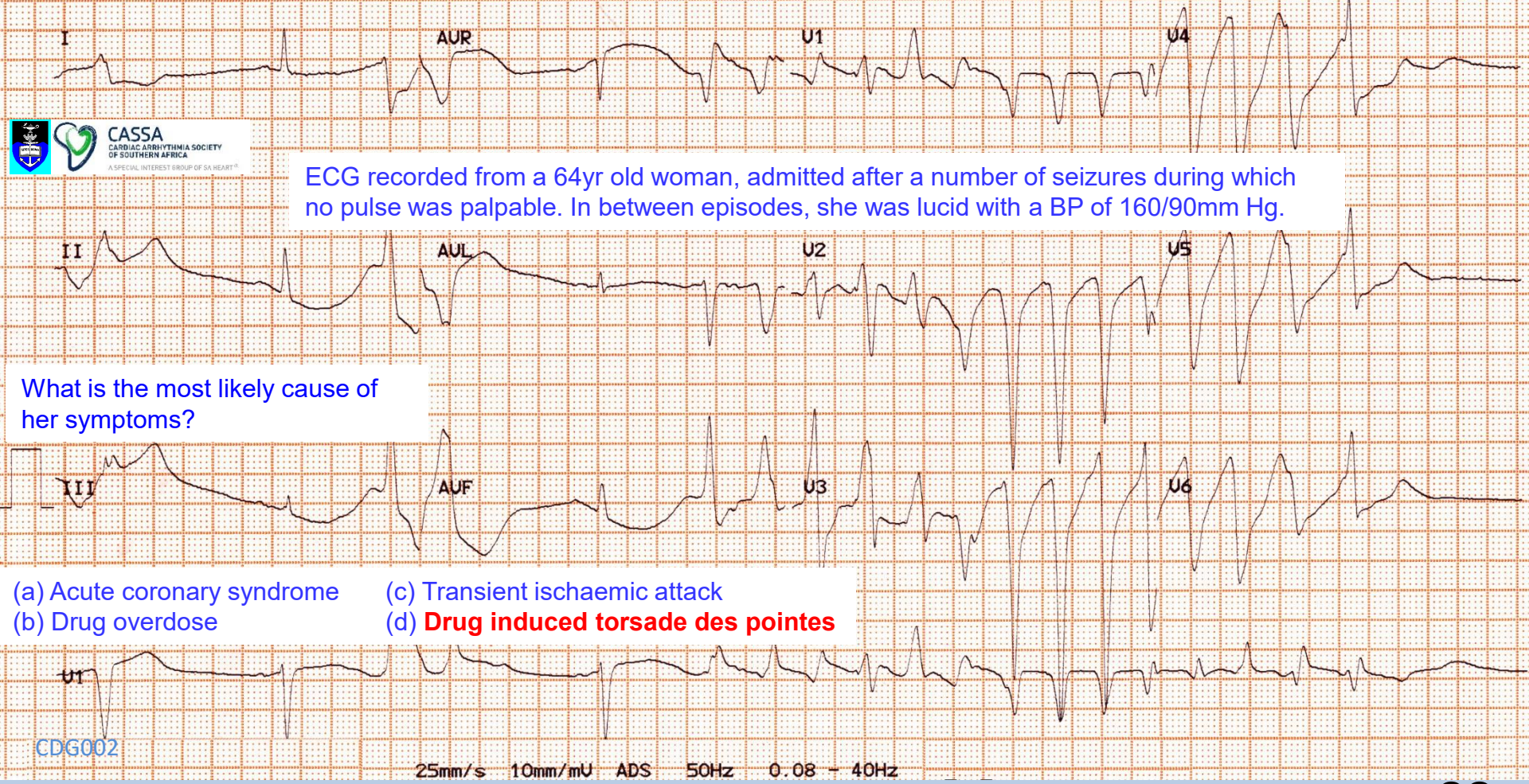
ECG recorded from a 64yr old woman, admitted after a number of seizures during which no pulse was palpable. In between episodes, she was lucid with a BP of 160/90mm Hg.

What is the most likely cause of her symptoms?

(a) Acute coronary syndrome
(b) Drug overdose
(c) Transient ischaemic attacks
(d) Drug induced torsade des pointes

SAA004


I
AUR
U1
U4
II
AUL
U2
U5
III
AUF
U3
U6
U1
CDG002
25mm/s 10mm/mV ADS 50Hz 0.08 - 40Hz



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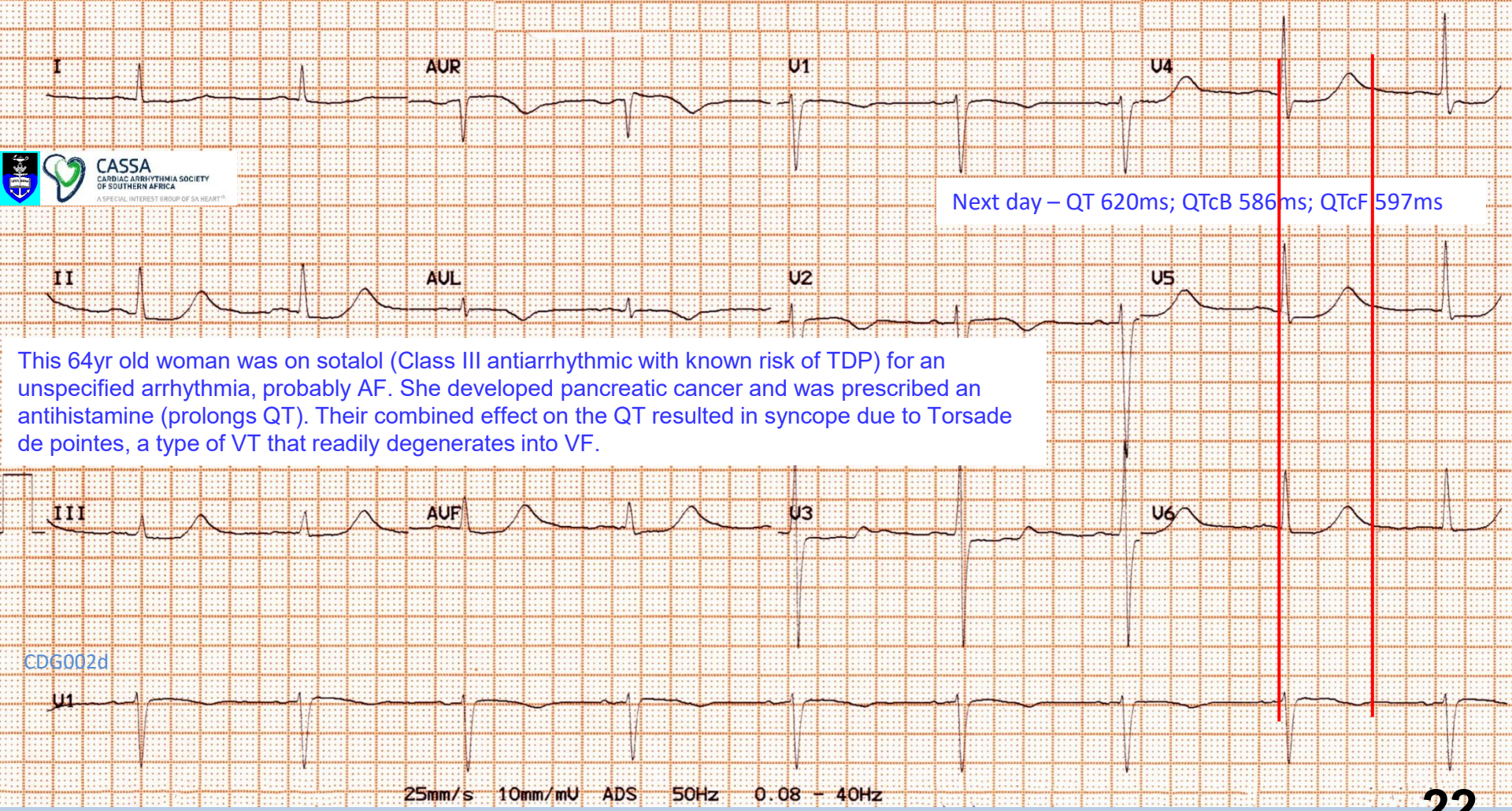
(c) Transient ischaemic attack
(d) **Drug induced torsade des pointes**



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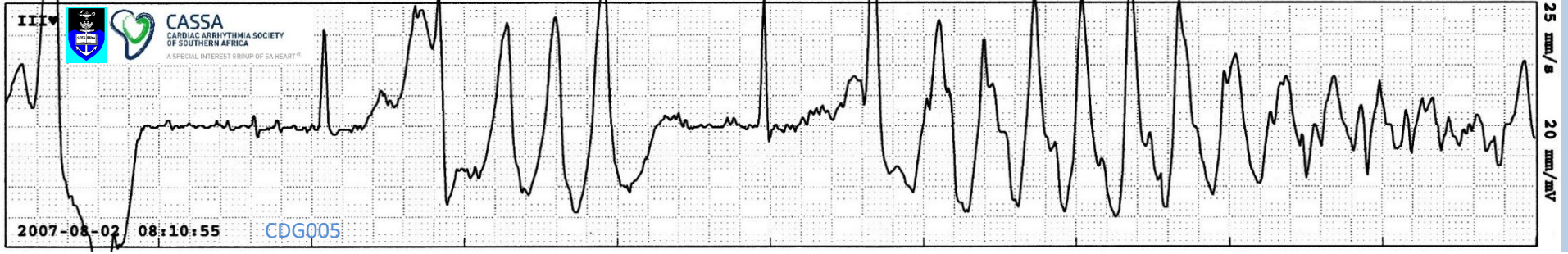
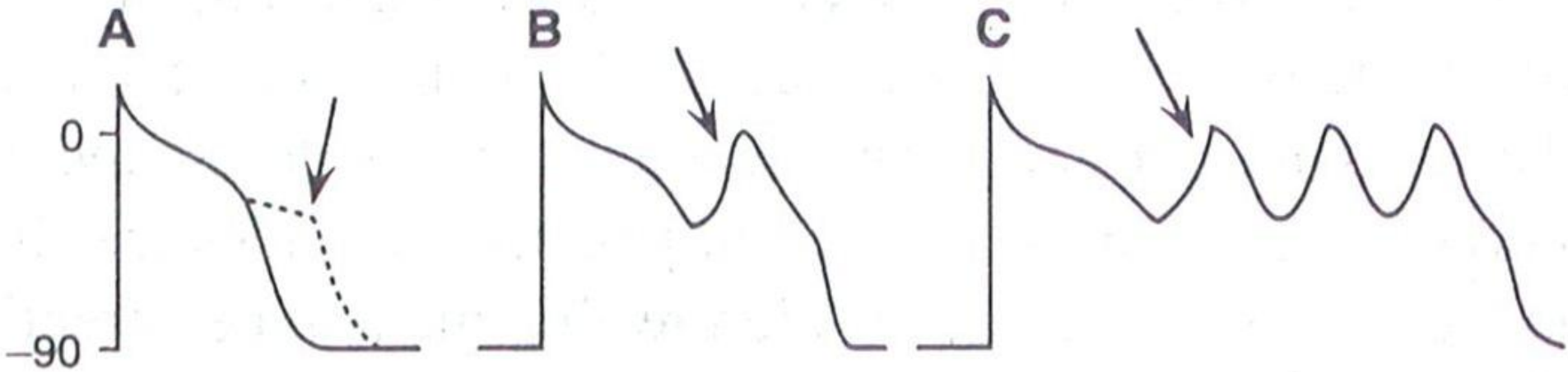
Next day – QT 620ms; QTcB 586ms; QTcF 597ms

This 64yr old woman was on sotalol (Class III antiarrhythmic with known risk of TDP) for an unspecified arrhythmia, probably AF. She developed pancreatic cancer and was prescribed an antihistamine (prolongs QT). Their combined effect on the QT resulted in syncope due to Torsade de pointes, a type of VT that readily degenerates into VF.

CDG002d





- Triggered activity: abnormal Action Potential in assoc with prior AP

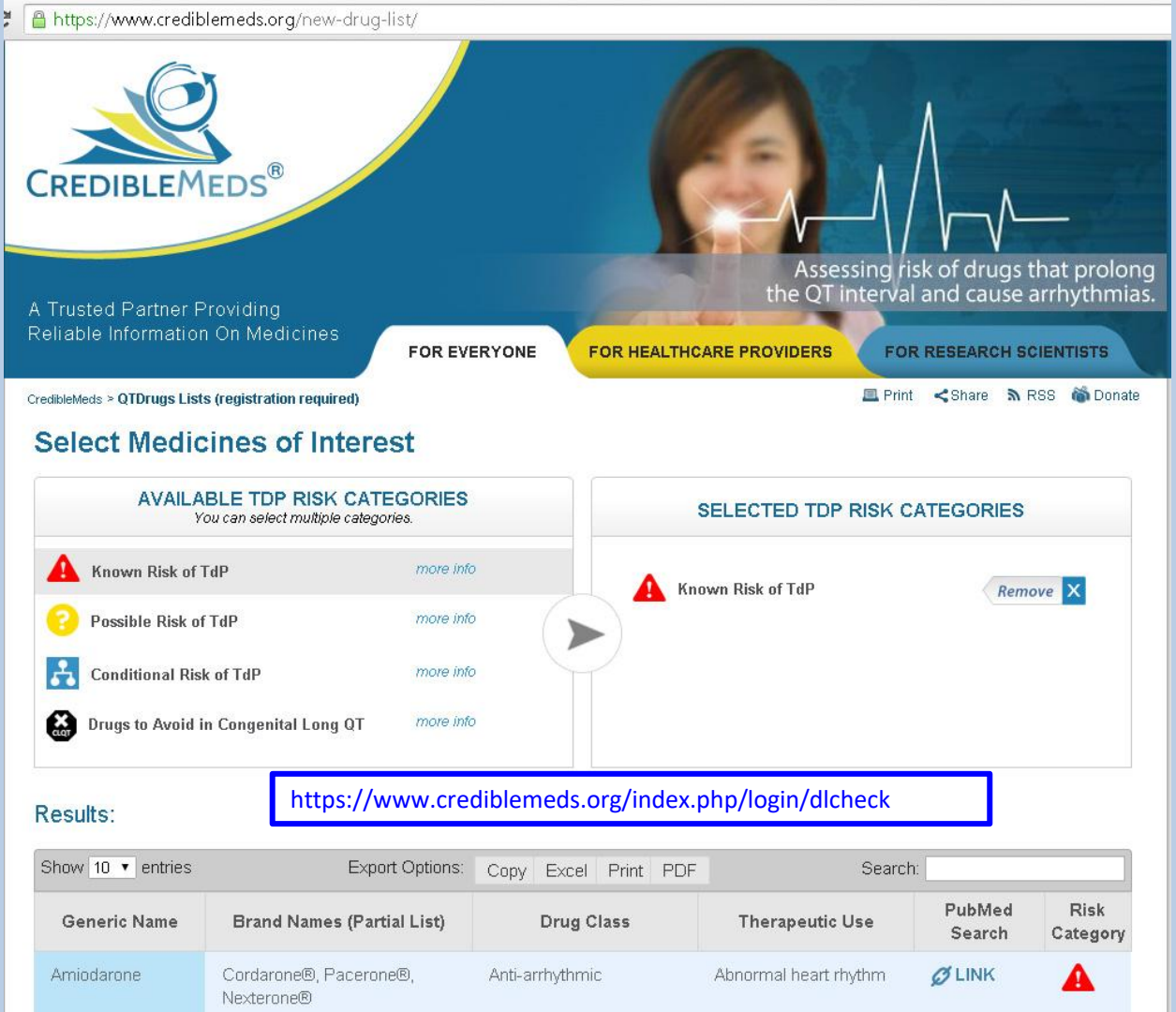
Prolonged action potential predisposes to further spontaneous depolarizations that may be self-perpetuating

Risk factors for Torsade de Pointes

- Female gender
- QT prolonging drug
- Hypokalaemia
- **Drug combinations (check Drugs.org for interactions)**
- Sub-clinical K+ channel abnormalities (?inherited)
- Kidney or liver dysfunction

Drug groups with risk of TDP

- Class III antiarrythmics (e.g. sotalol)
- Antibiotics (e.g. quinolones, erythromycin)
- Antipsychotics (e.g. haloperidol)
- Antidepressants (e.g. escitalopram)
- Anti-emetics (e.g. odensitron) + GIT motility drugs
- Antihistamines
- Cancer drugs – many
- Antiviral (amantadine)
- Antimalarial (quinine, halofantrine)
- Antifungal (fluconazole)



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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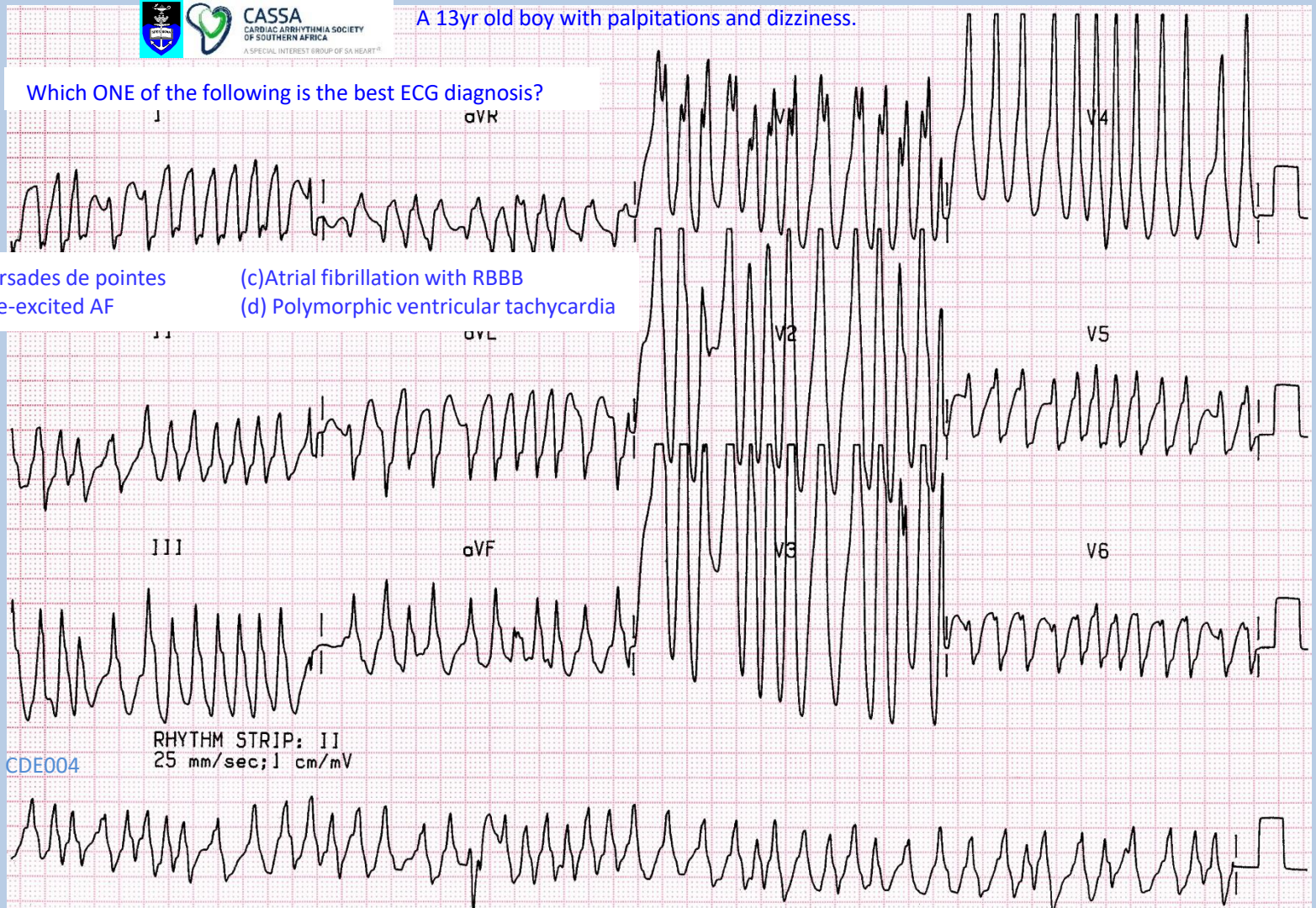
A 13yr old boy with palpitations and dizziness.

Which ONE of the following is the best ECG diagnosis?

(a) Torsades de pointes
(b) Pre-excited AF
(c)Atrial fibrillation with RBBB
(d) Polymorphic ventricular tachycardia



CDE004

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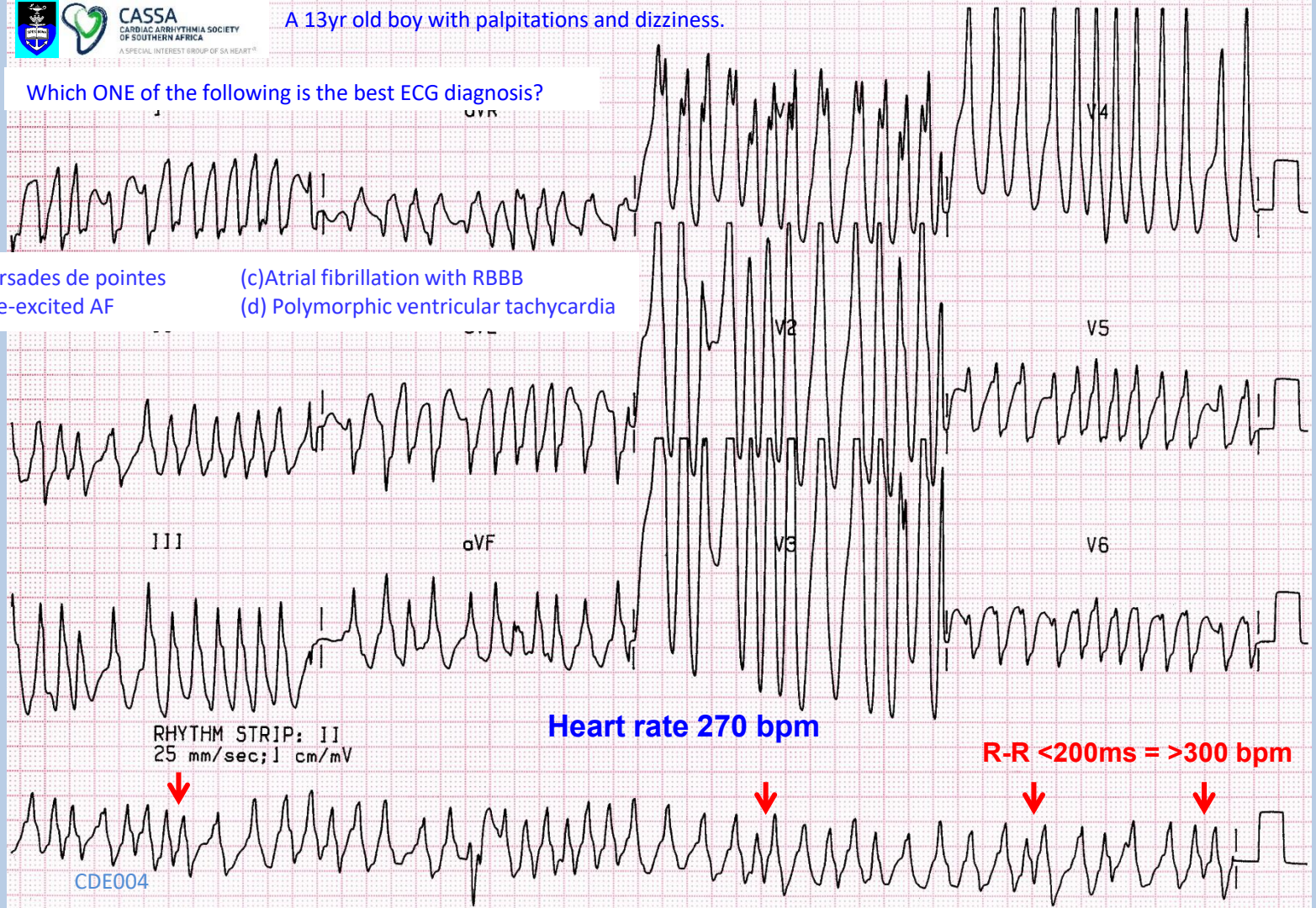

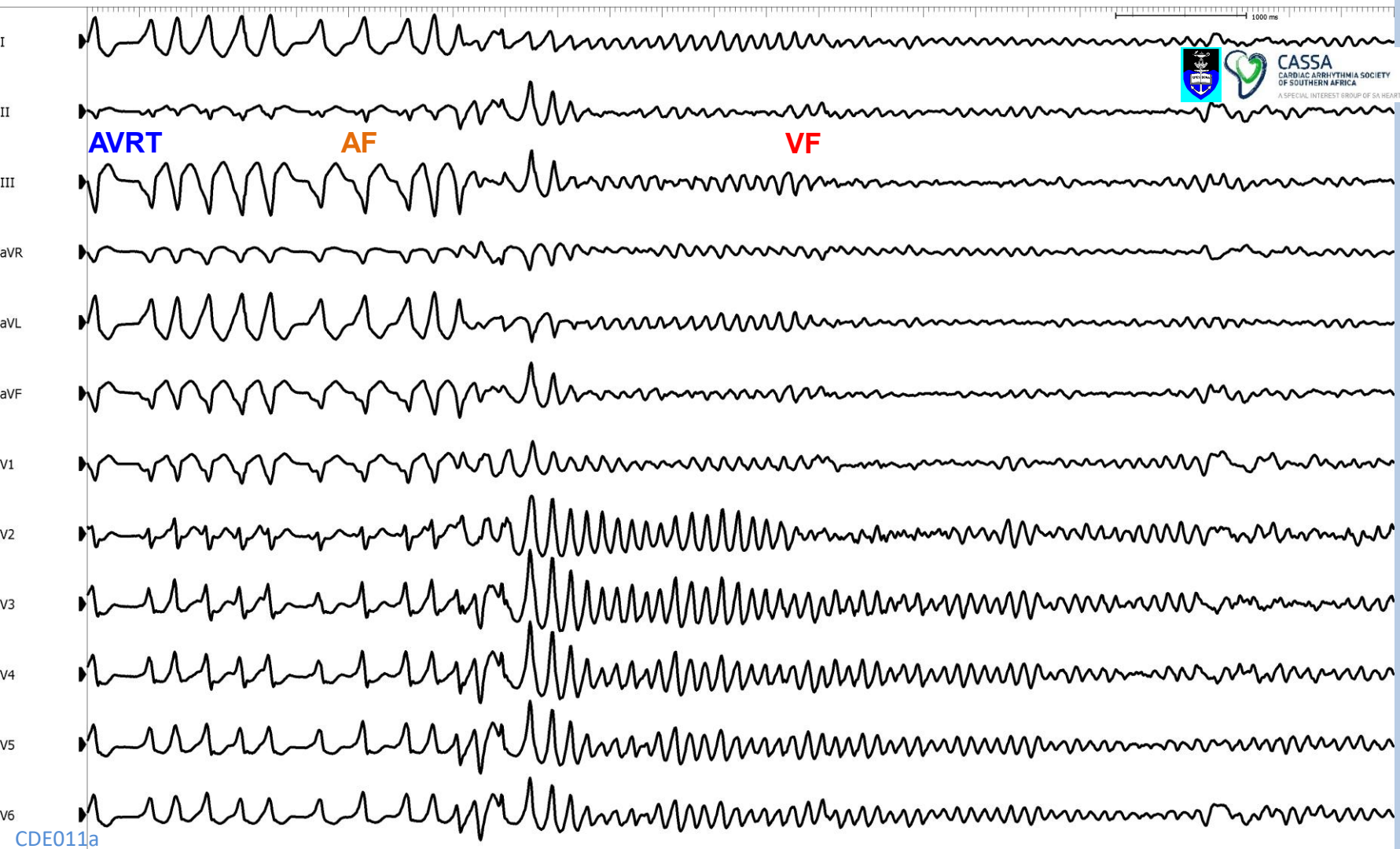
1000 ms
I
II
III
aVR
aVL
aVF
V1
V2
V3
V4
V5
V6
AVRT
AF
VF
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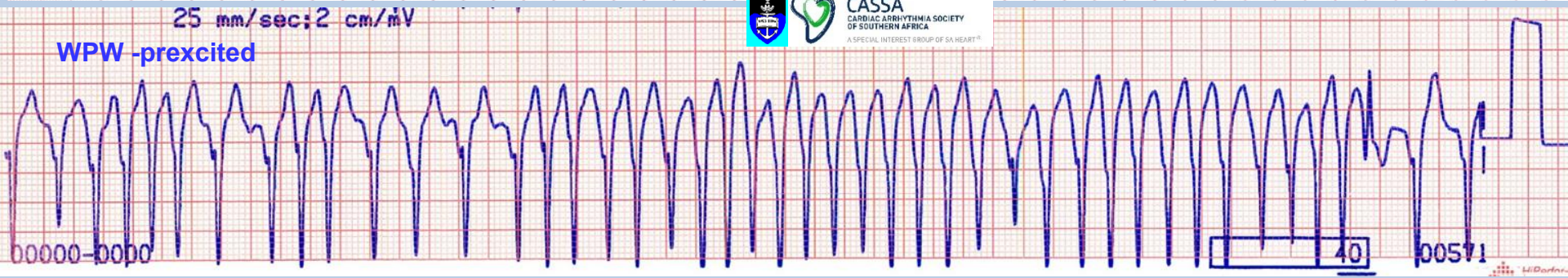
CDE011a

Irregular wide QRS tachycardias – Atrial fibrillation

Typical RBBB

Typical LBBB



WPW -prexcited

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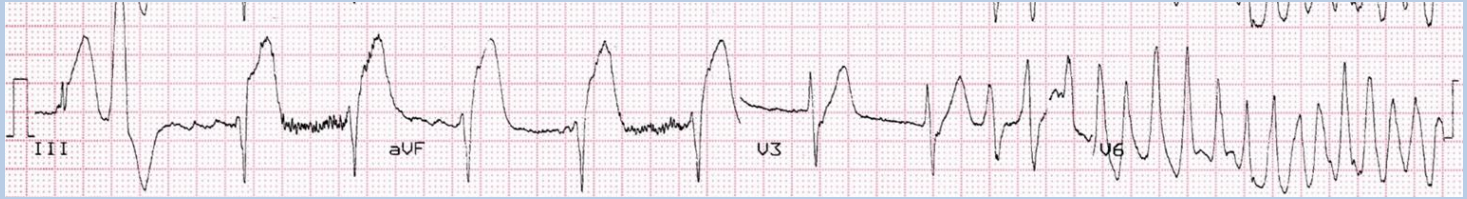
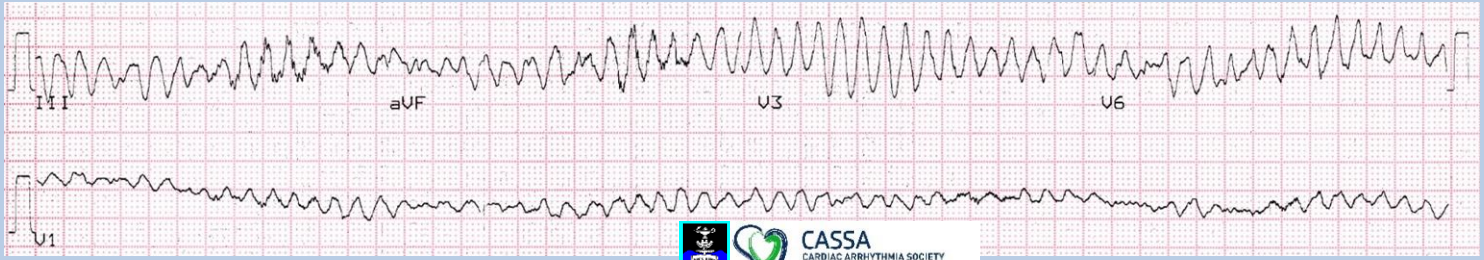
Irregular wide QRS tachycardias – Polymorphic VT

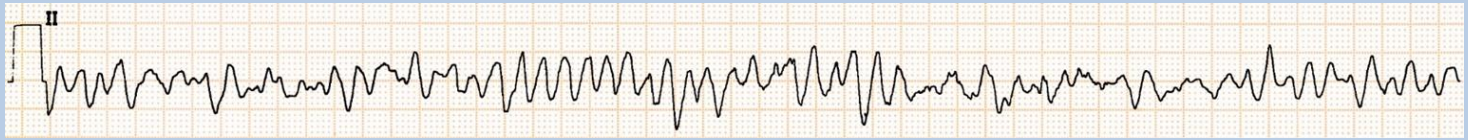


Inferior STEMI
Onset of
polymorphic VT



Inferior STEMI
VF

Polymorphic VT



VF

- 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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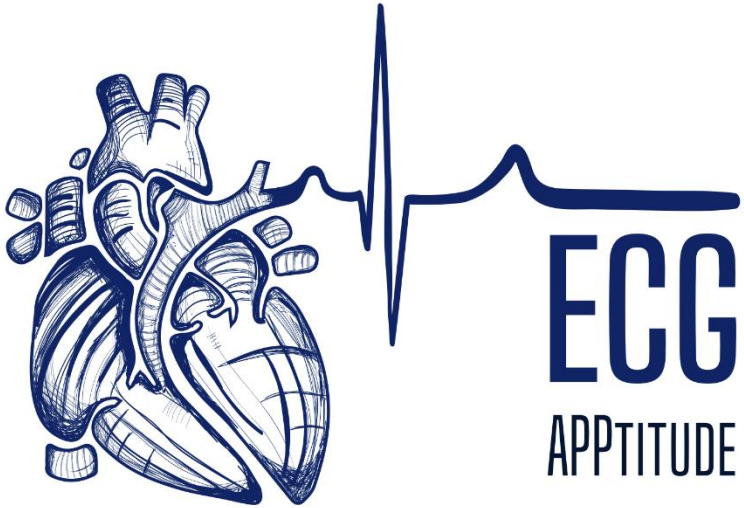

ECG
APPTITUDE

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Download on the App Store

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


ECG
APPTITUDE

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/